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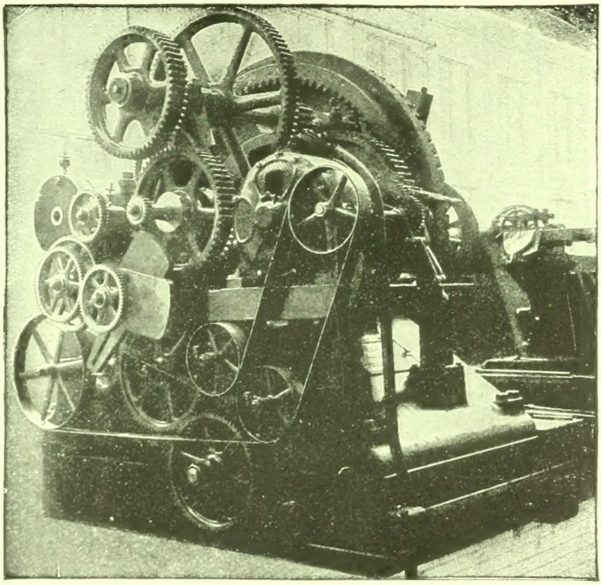

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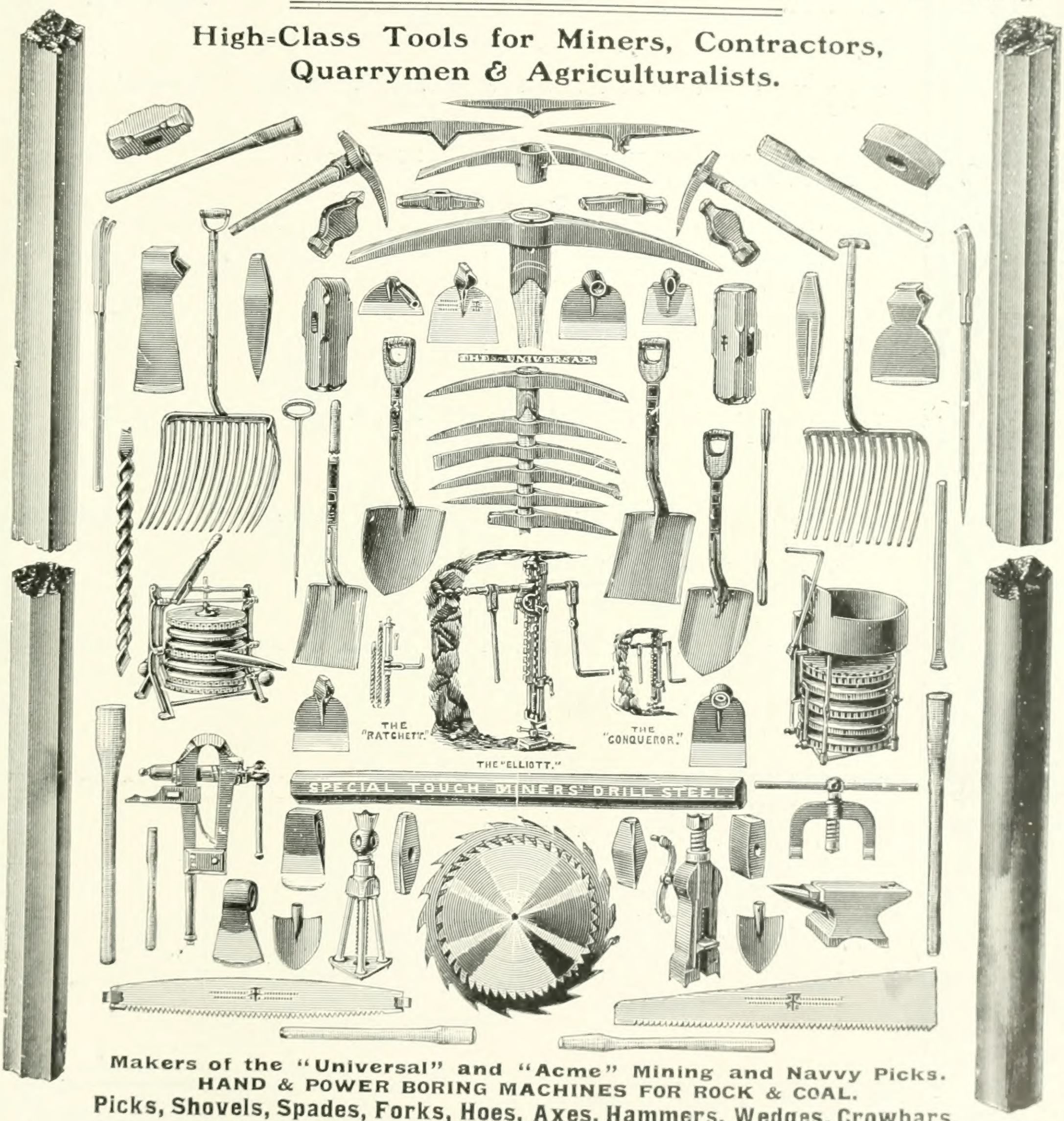
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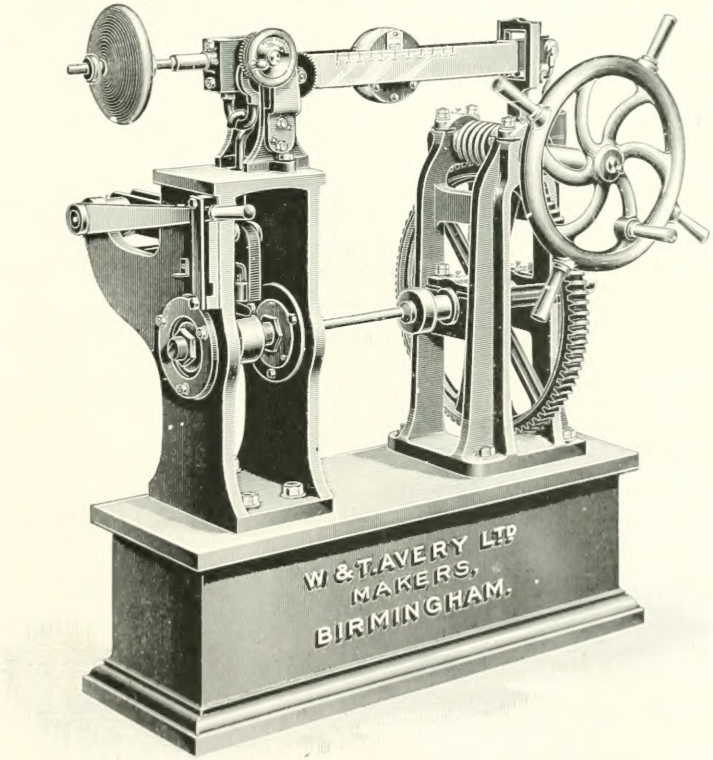

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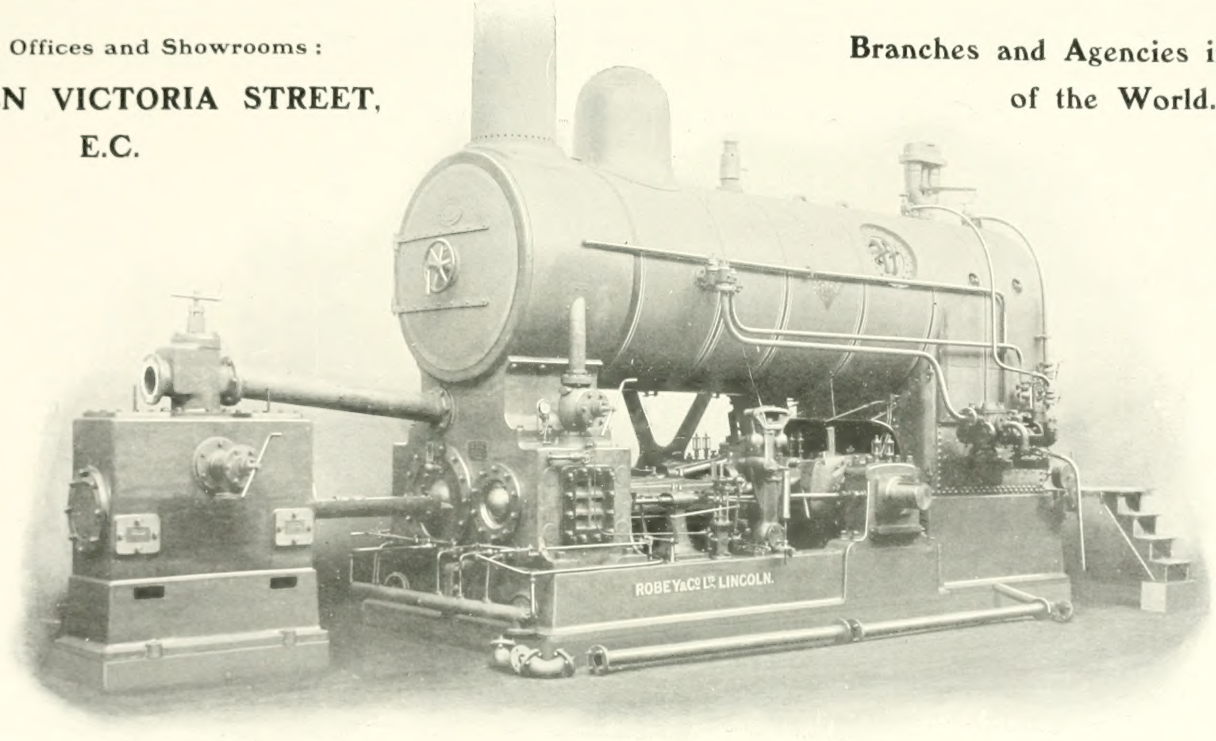

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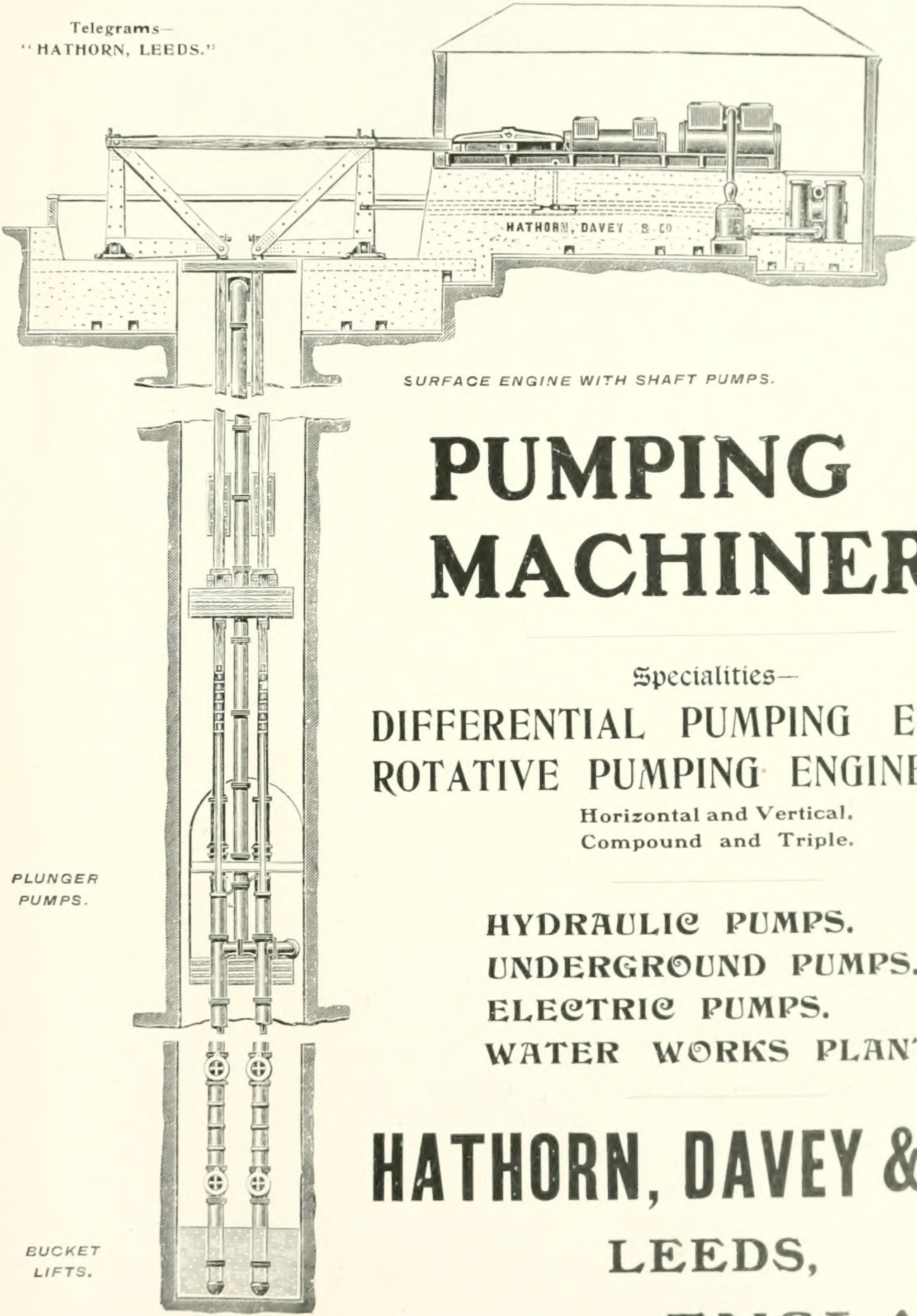

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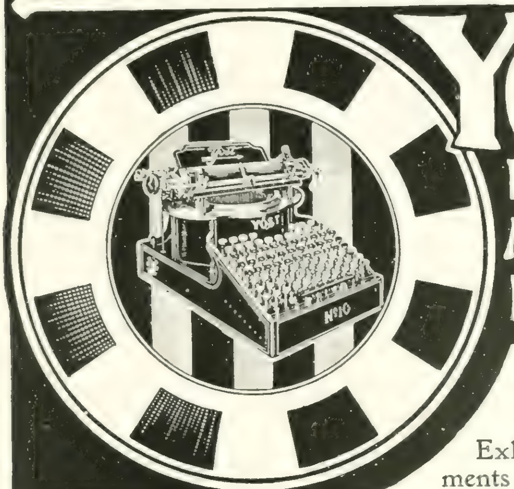

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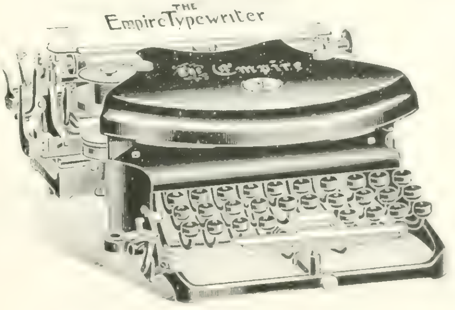

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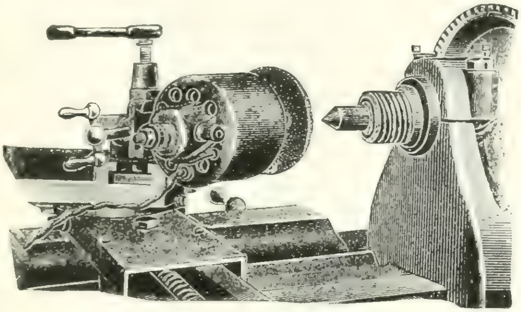

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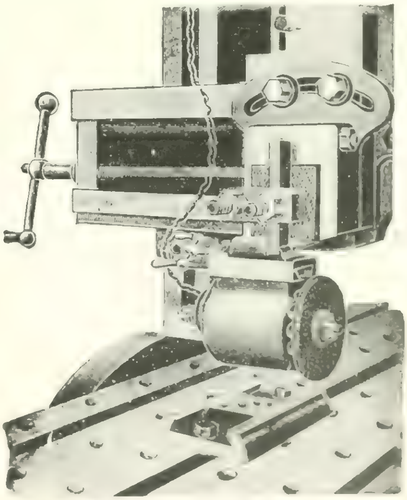

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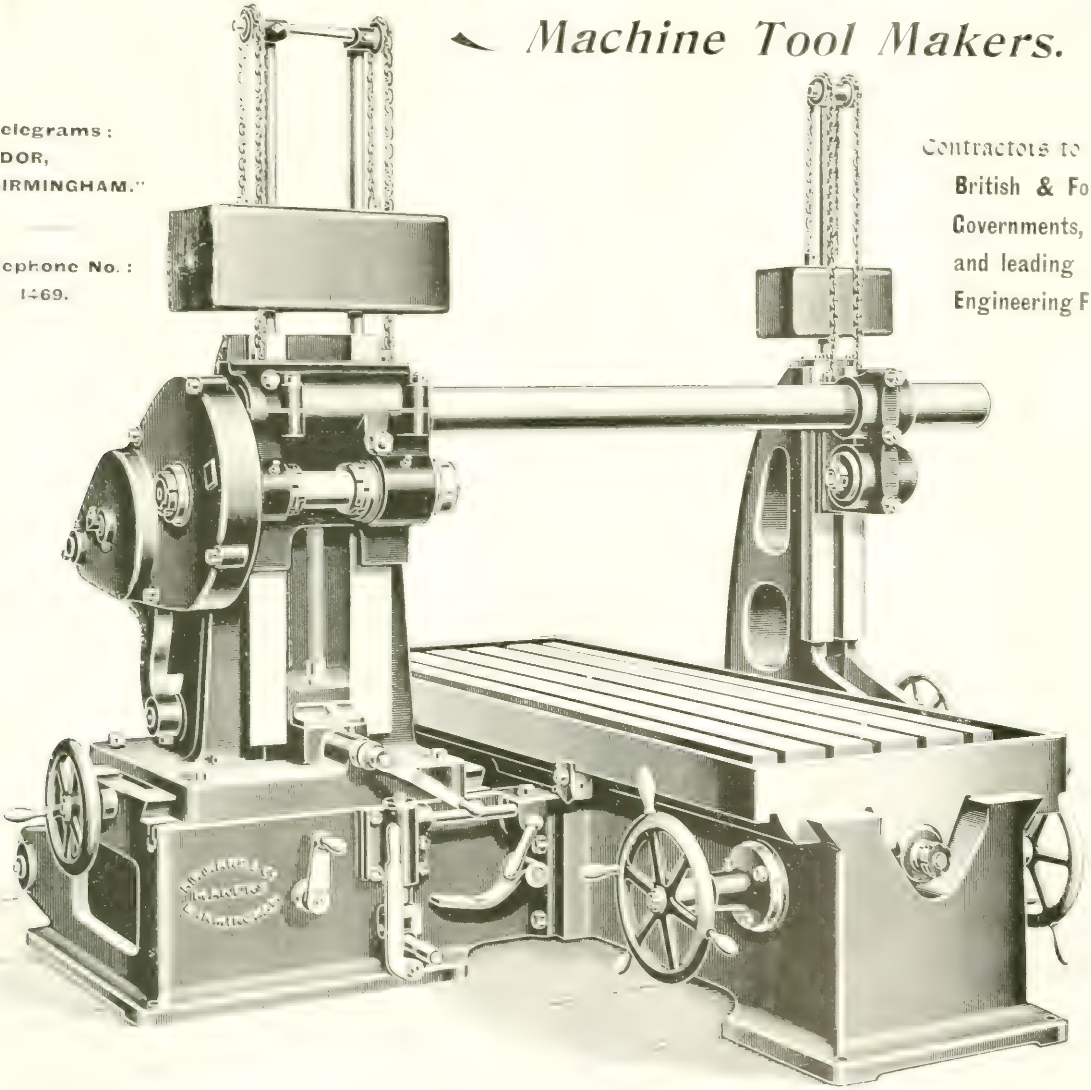

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Minimum ,, ,, ,, ,,	3 ,, 4 ,,
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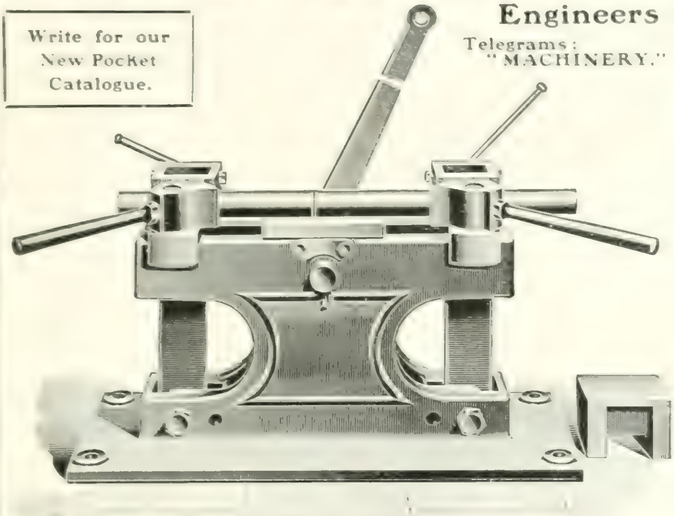

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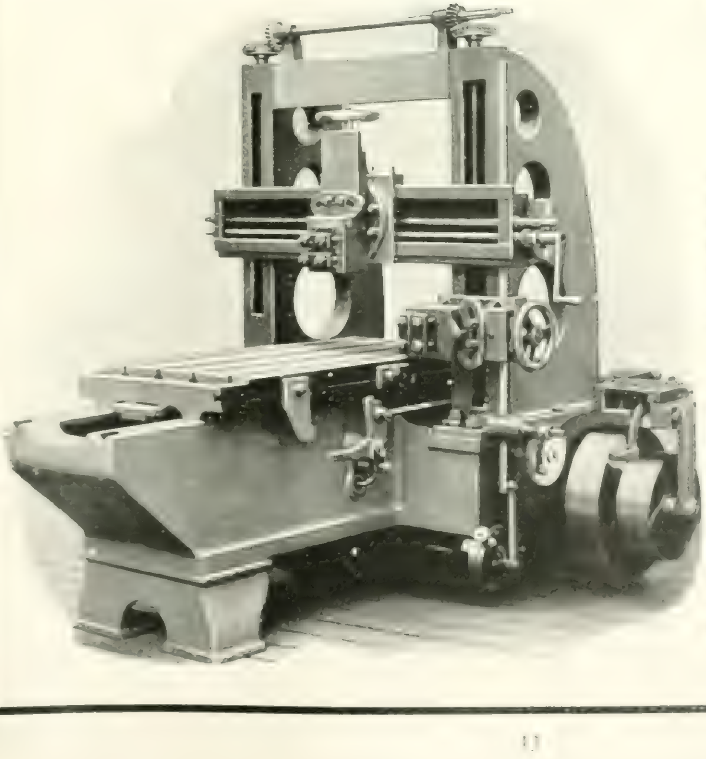

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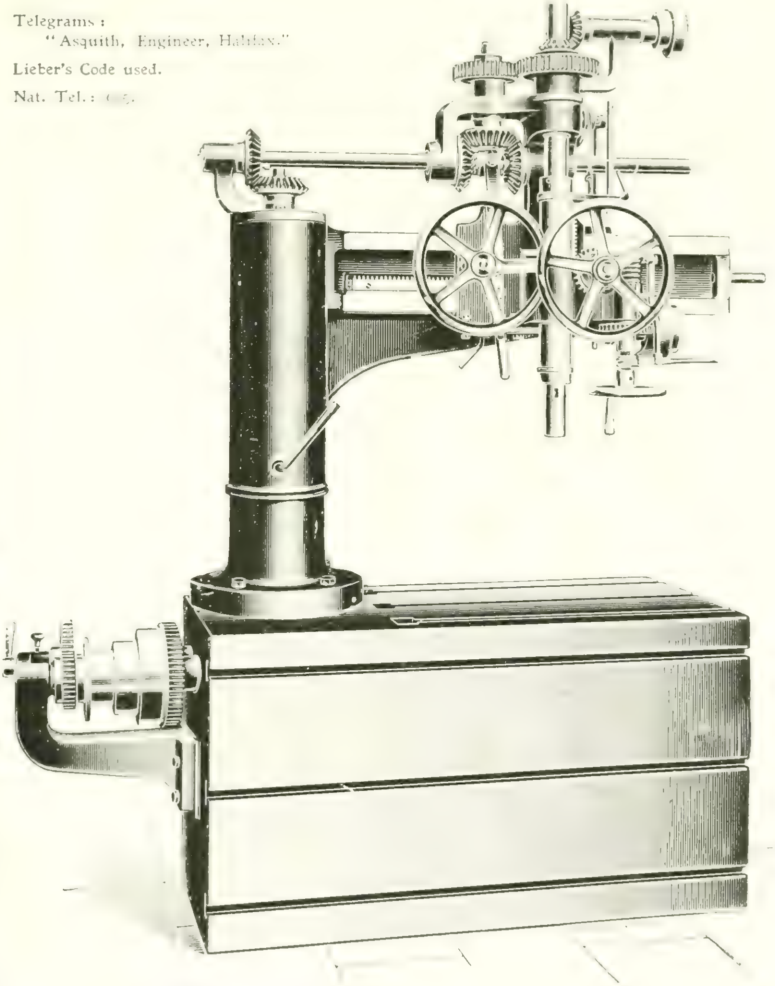

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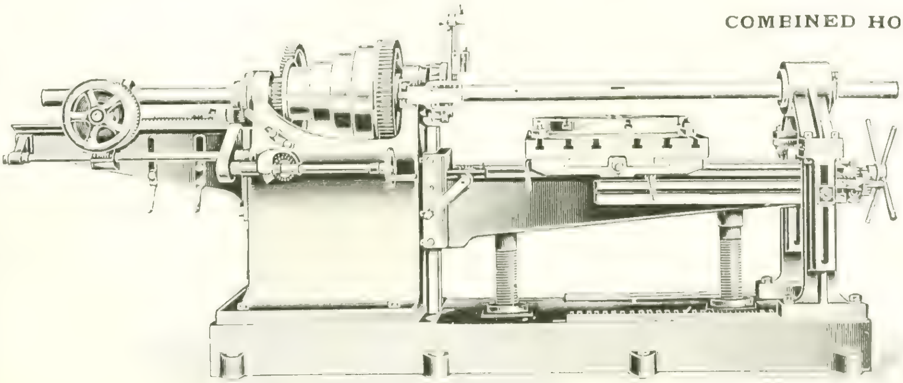

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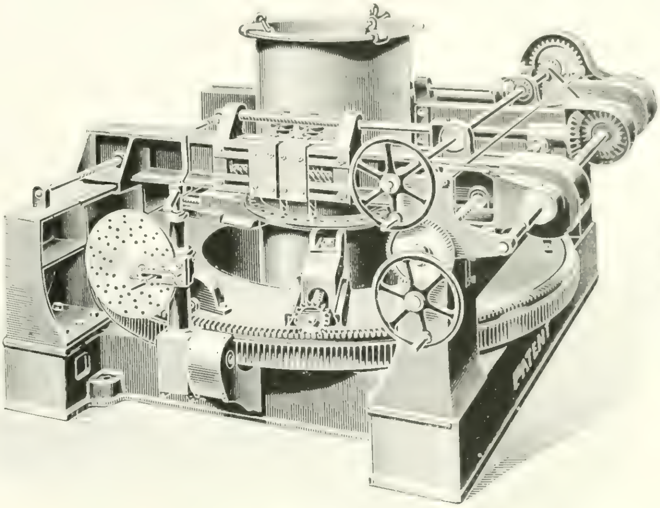

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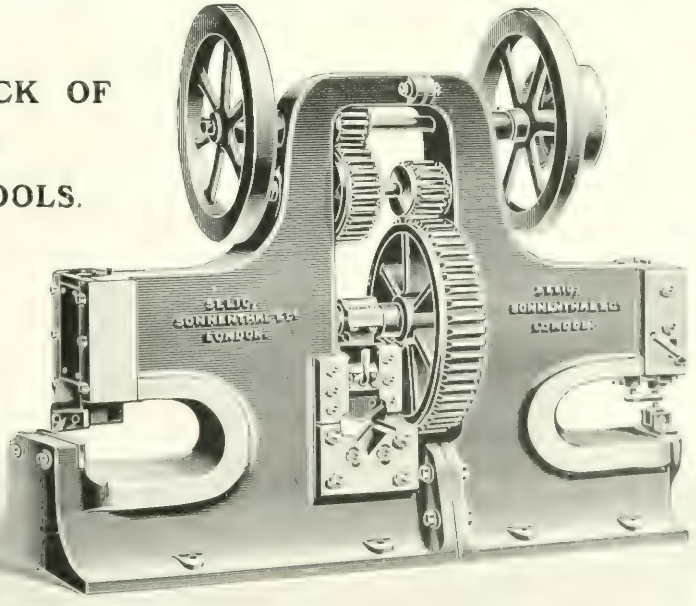

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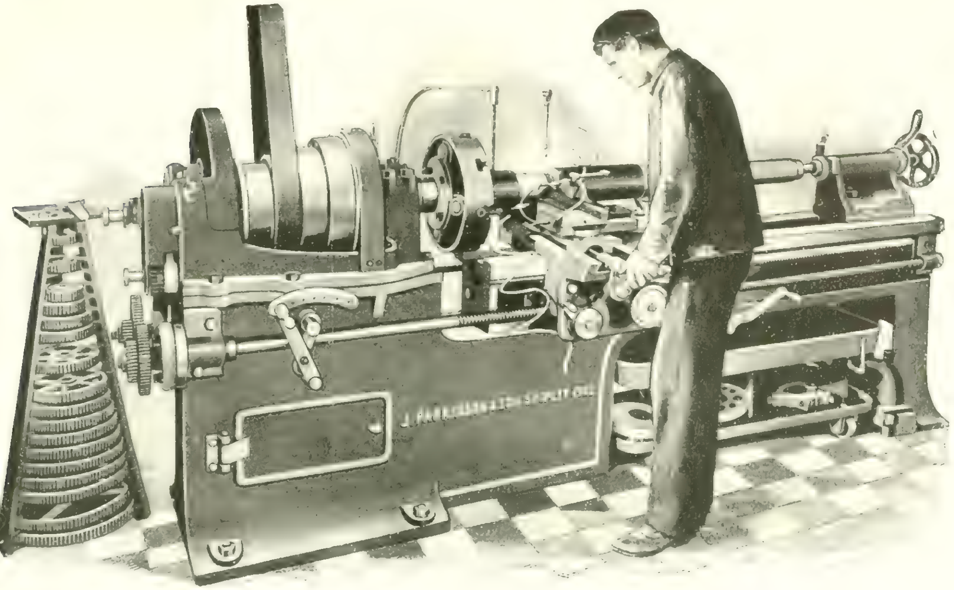

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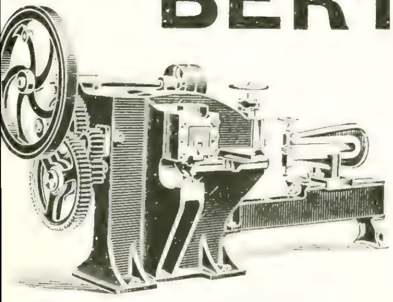

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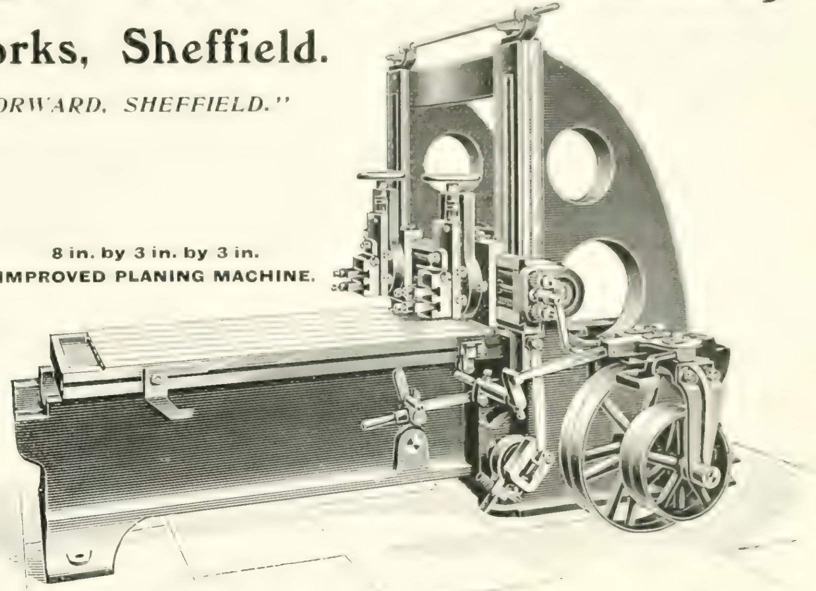

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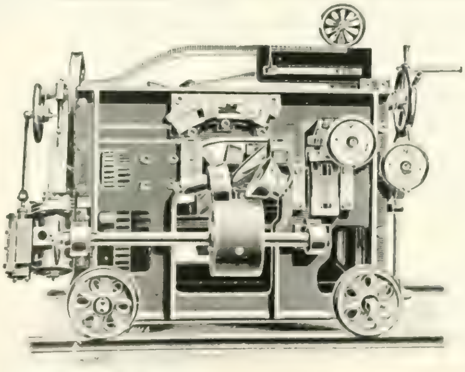

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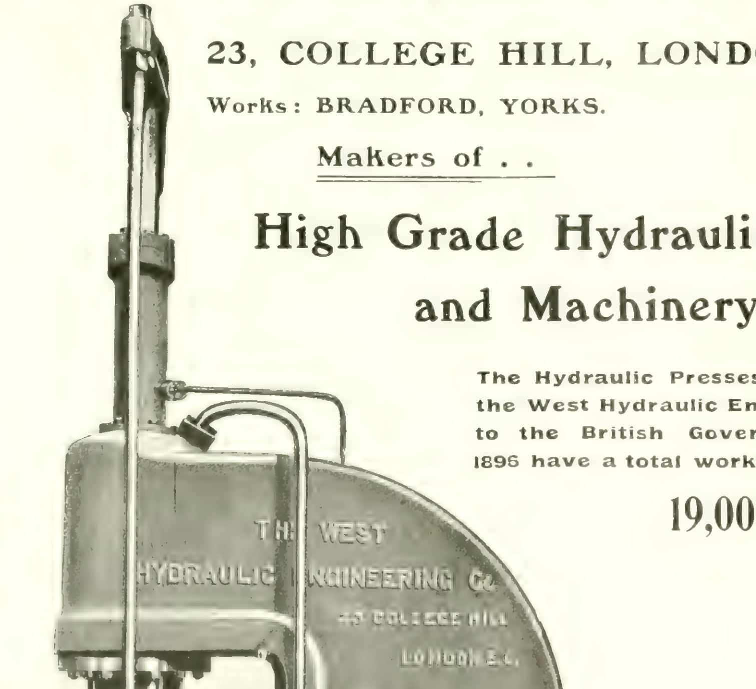

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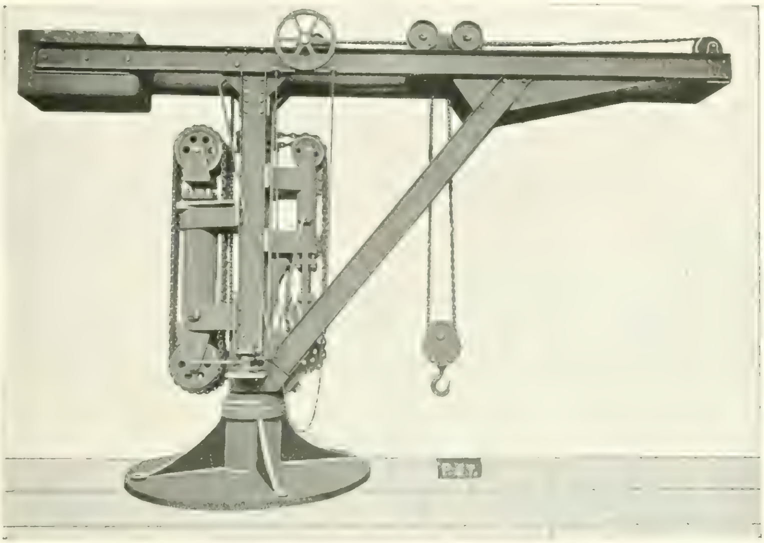

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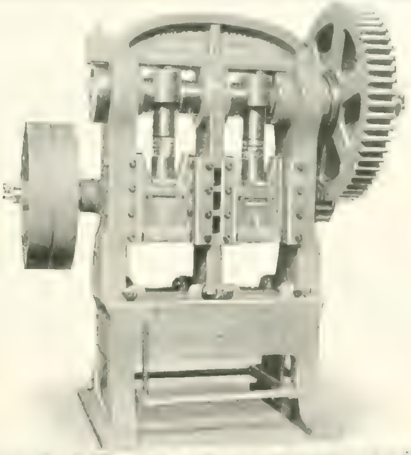

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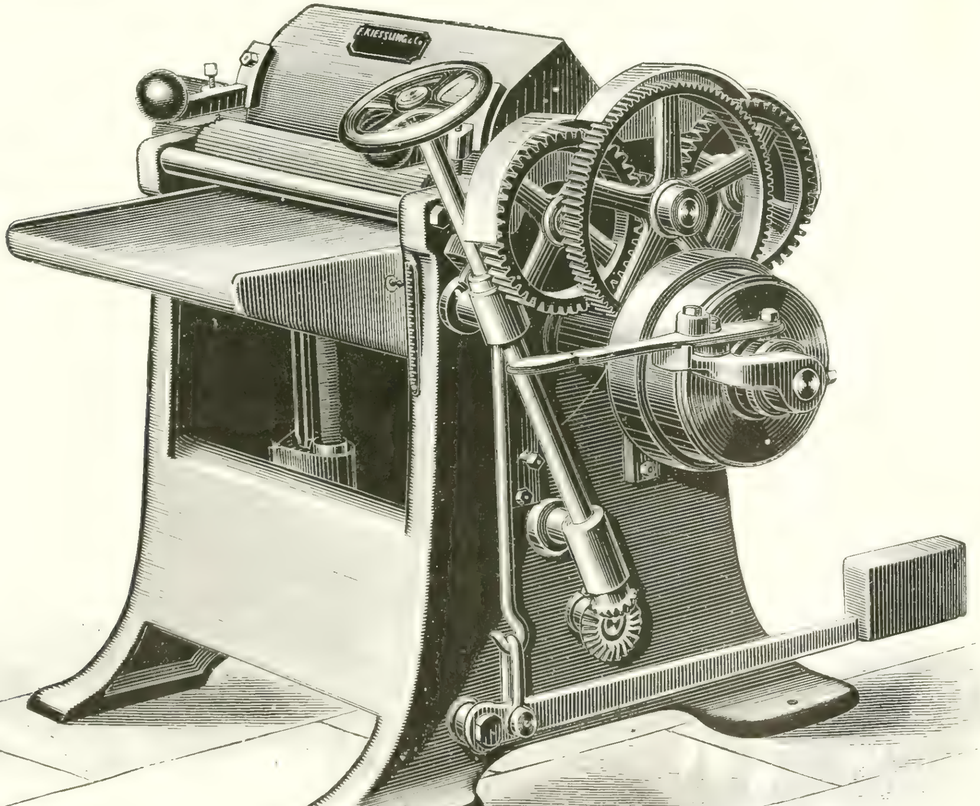

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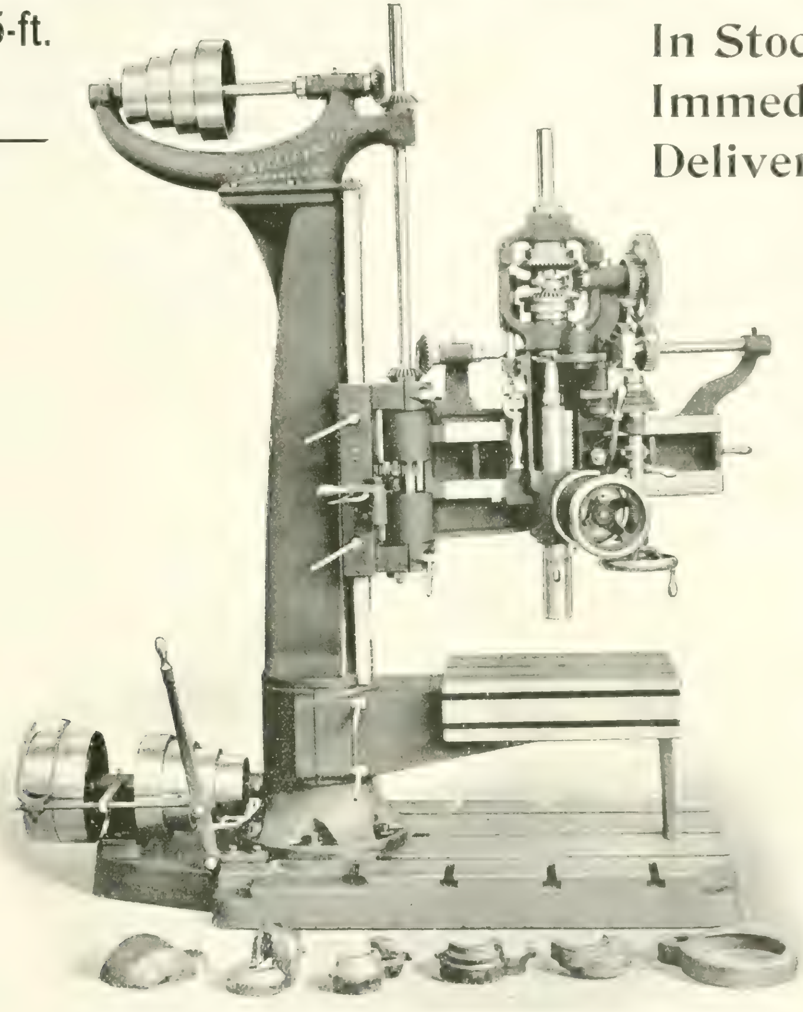

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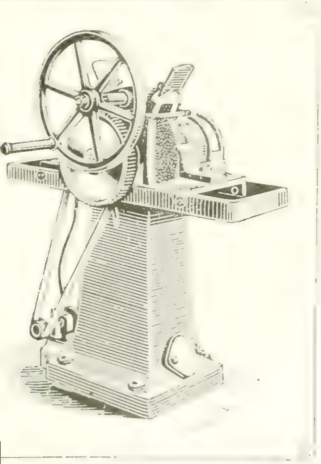

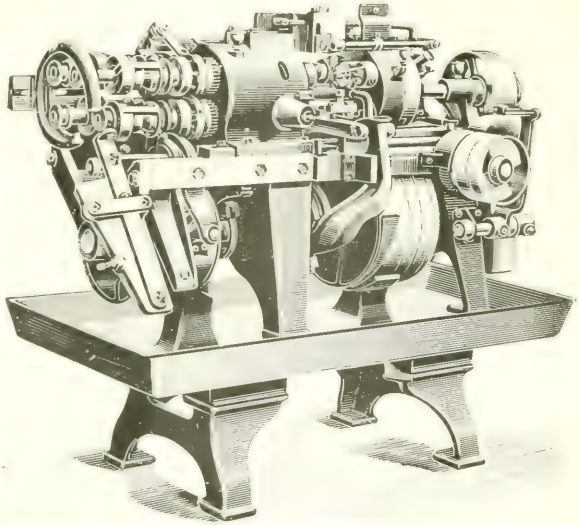

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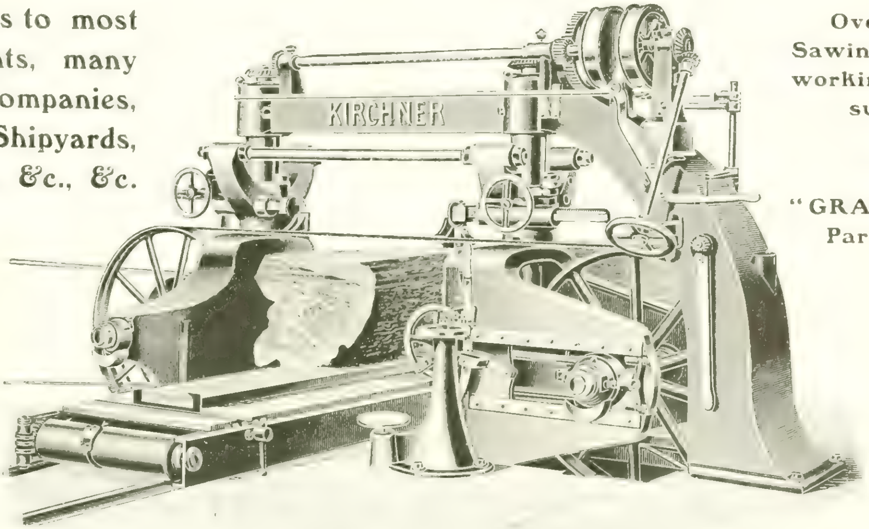

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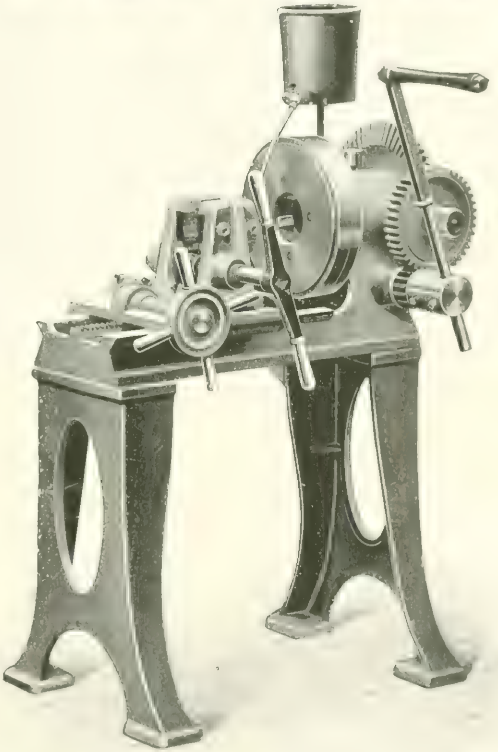

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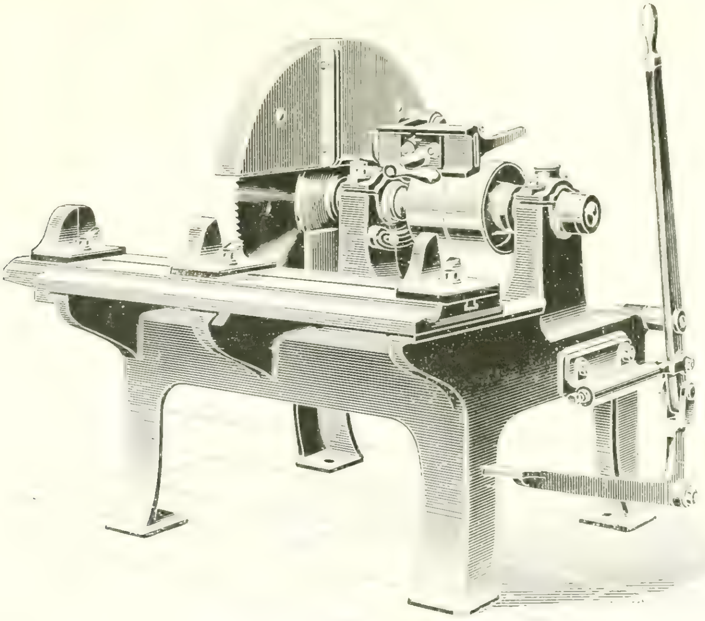

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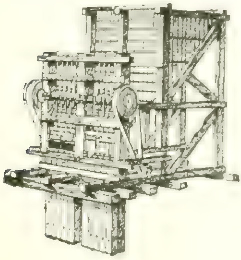

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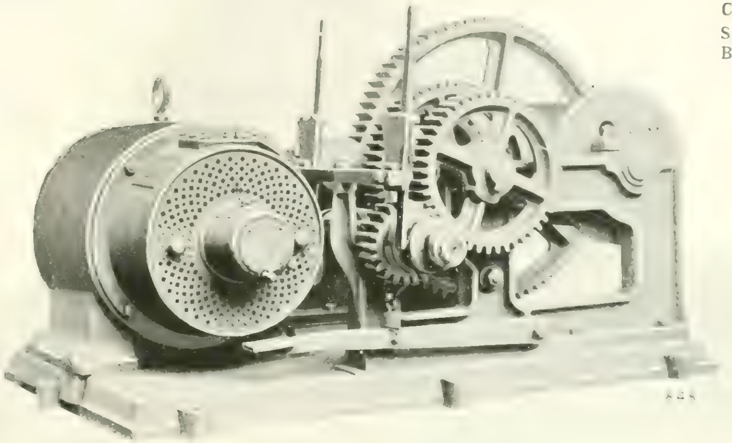

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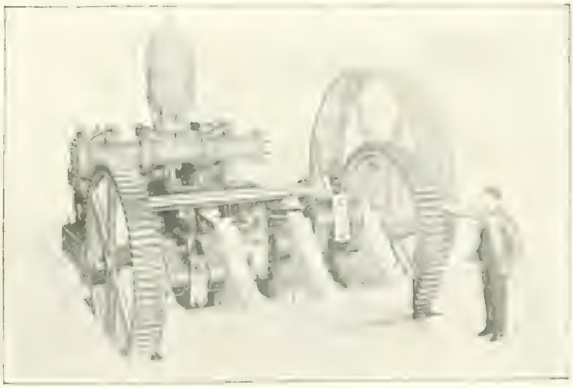

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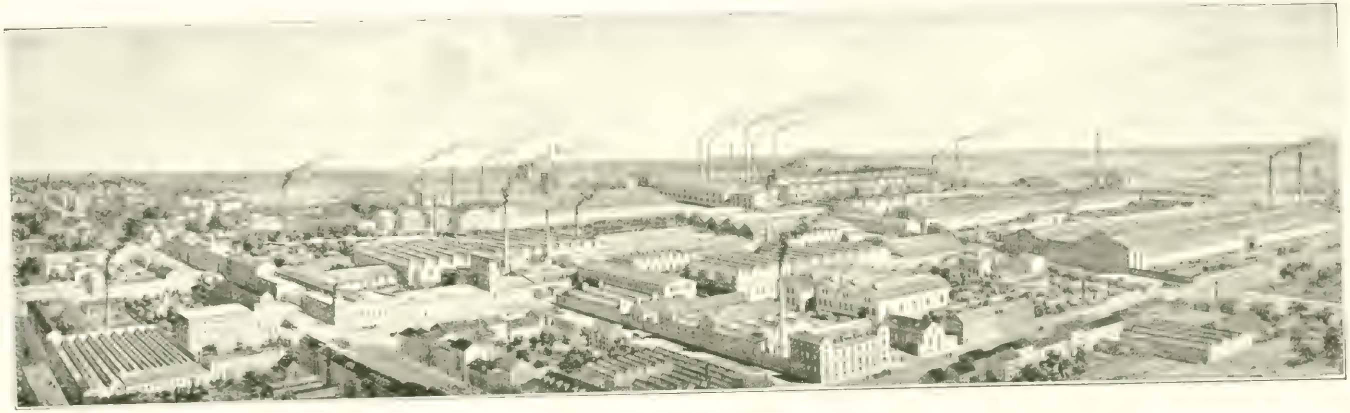

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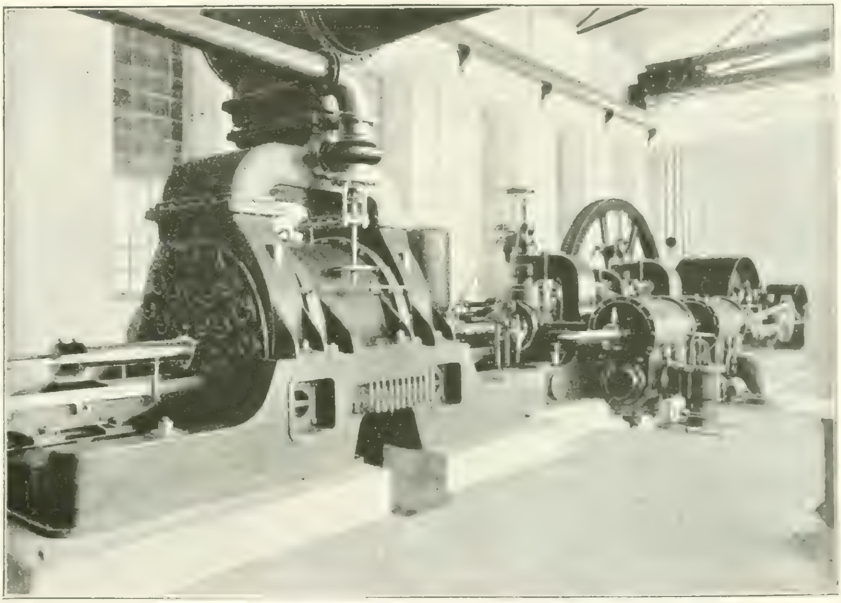

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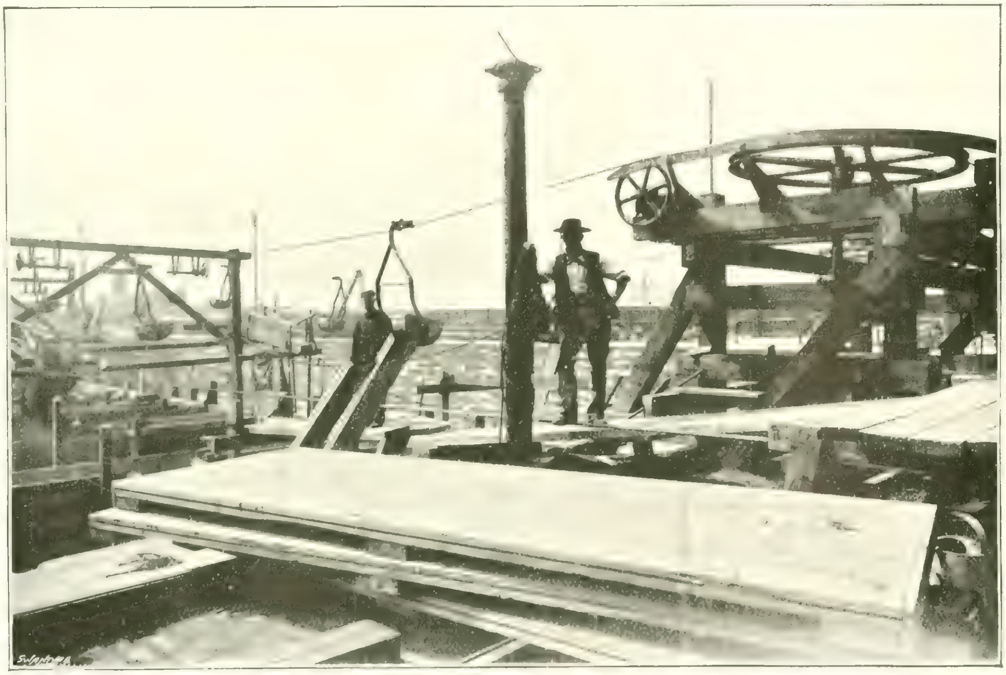

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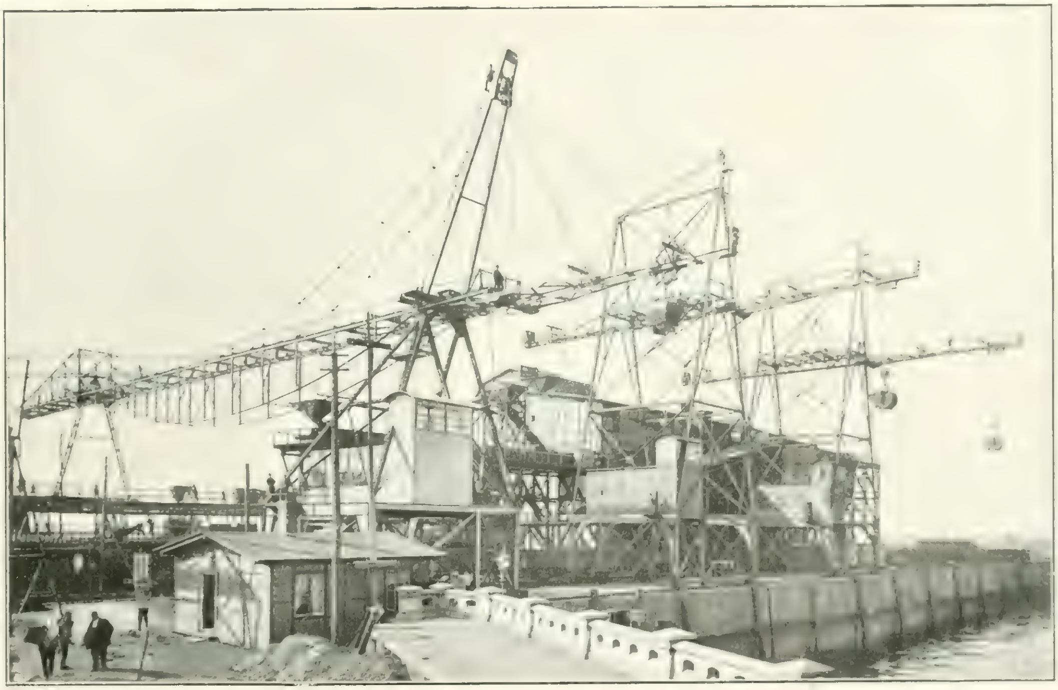

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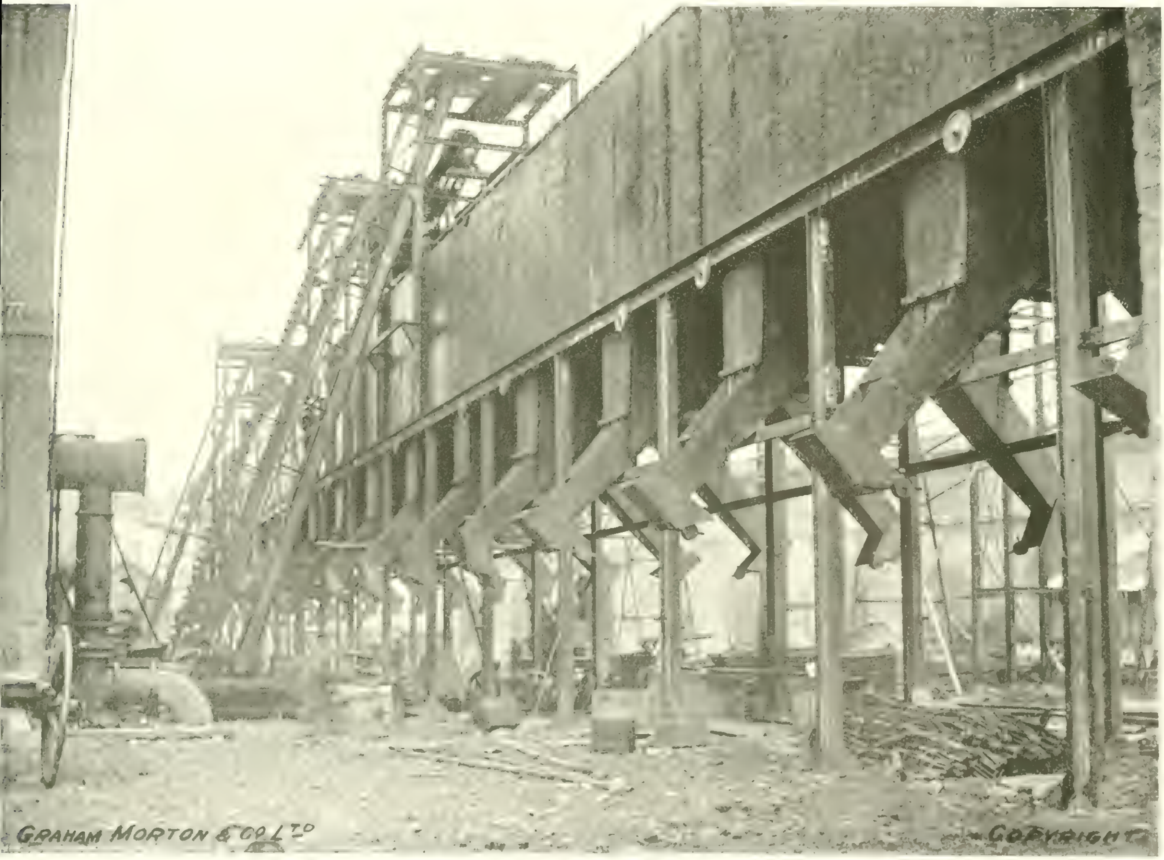

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OVER 15,000 SOLD.

Supplied to 500 British and Foreign Railways.
Adopted by 26 Governments and all leading Firms.
Exclusively used by the Great Military and Naval Powers.

No. 0.	Lamp. 500 Candle power.	Small Hand pattern	£7	7s.
" 1.	Do. 500 or 1,500 Candle power.	Hand pattern	£10	0s.
" 2.	1,500 or 2,500 Candles.	Useful and Portable pattern	£15	10s.
" 3.	2,500 or 3,500 Candles.	Manchester Ship Canal pattern	£16	10s.
" 4.	3,500 or 5,000 Candles.	A most powerful Lamp	£17	15s.

Burns either heavy Wells' Oil or Petroleum, but the former is very cheap and gives about 30 per cent. more light than petroleum.

KETTLE TORCH LAMPS.

The Miner's Favourite.
Thousands Sold.

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Large Flaming Light.

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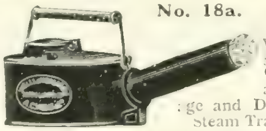
No. 28 same shape as above, but having two Wicks, 6 Pints, **9s.** each,



No. 18a. A Splendid Lamp, fitted with 2 in. Wick, 5 Pints capacity **9s.** each. Suitable to Sewerage and Drainage Work Steam Trawlers, &c.

WELLS' OIL GAS GENERATING LAMPS.

Light from Kerosene or Petroleum without Wick, Smoke, or Smell at less than One Penny per hour.

Perfect Safety.
No Explosive Naphtha
and
Economical.
Unaffected by Wind.

	Each
No. 12, 3 hours	11 9
No. 12A, with Tripod	13 9
No. 13, 5 hours	14 -
No. 13A, with Tripod	17 -
No. 14, 7 hours	16 -
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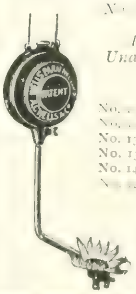
Extra Burners for above, **2s.** each.



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Applied at a speed of from 8 to 10 square yards per minute, in a manner superior to brush work.

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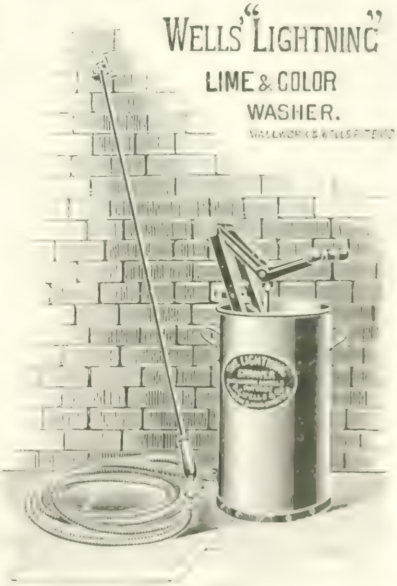

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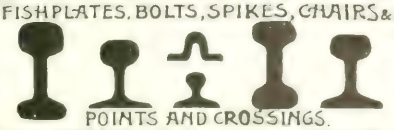

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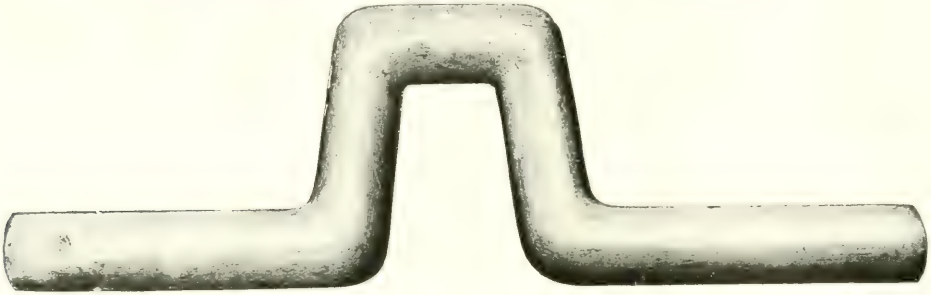

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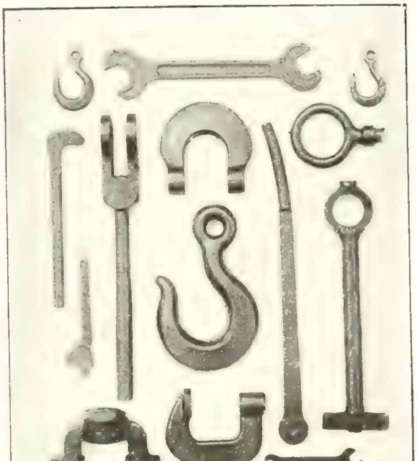

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You should use them instead of castings if you want Strength, Lightness and Finish. Inquiries solicited.

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The Engineering and Shipbuilding Stampers.

"Thin" Wrenches

For Check and Jamb, etc. Nuts are not common tools. We know of no other similar line. Nine sizes Single Head, twelve sizes Double Head.

Twenty-seven patterns of wrenches illustrated in

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Manufacturers of RIVETTED WORK of all . . Descriptions.

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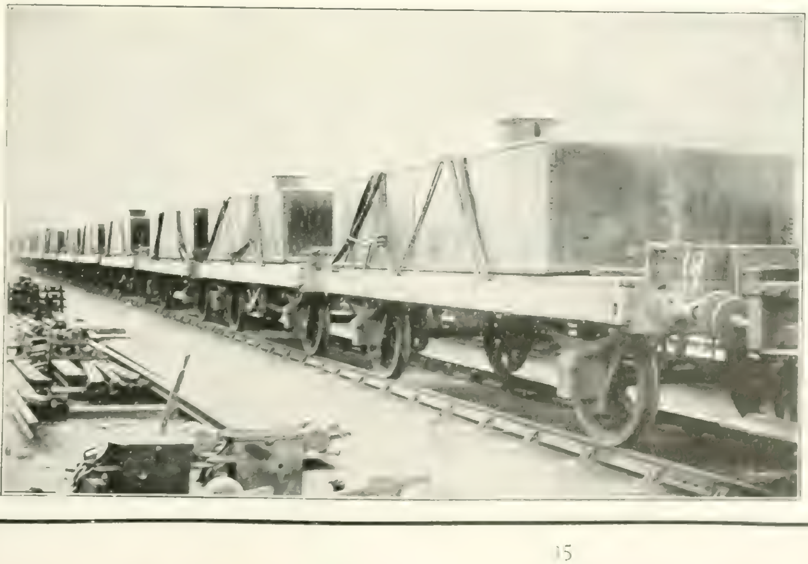

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IRON-PLATE and
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Railway Carriage Tanks
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PERFORATED SCREENS,
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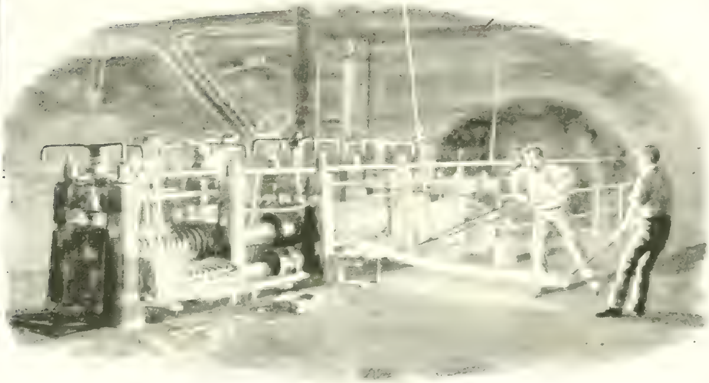

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Farnley **Bar Iron** is used in **Mining** for pit cages, suspending gear, and other important parts, and on all the leading **Railways** in Great Britain, India, and the Colonies, for shackles and other vital parts subjected to repeated shocks.

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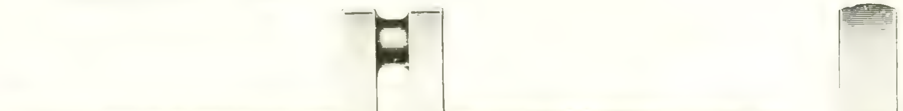
FOR CRANKS & FORGINGS OF EVERY DESCRIPTION WRITE TO



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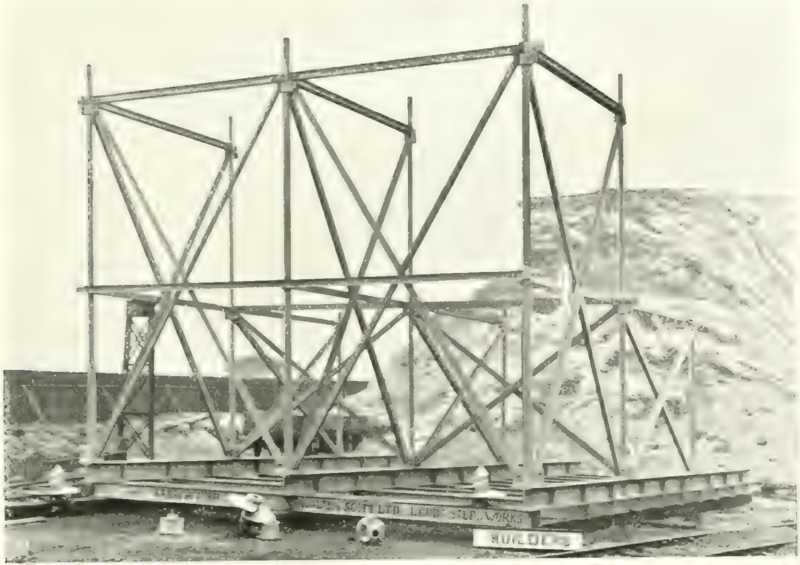
WALTER SCOTT, Ltd.,



One section of the steel work Karachi Pier, India. Photographed upside down. The extension of the Pier, for which we supplied the whole of the iron and steel work, was 2,048 feet in length, the weight of the material approximately being 2,000 tons.

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Rolled Steel Joists, Channels, etc.

Mild Steel Blooms, Billets, Slabs, Tinbars, Rounds, and Flats.

Speciality: Tramrails.

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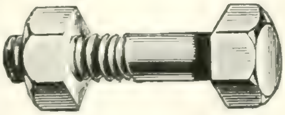
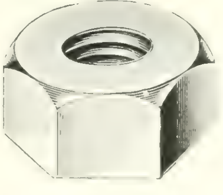
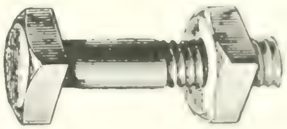


VICTORIA
BOLT AND NUT
WORKS,



BILBERRY
ST.,
MANCHESTER.



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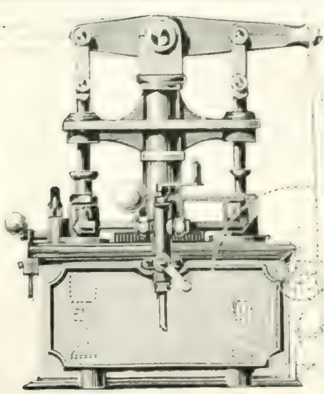

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EDWIN MILLS & SON,

Estd. 1810. Aspley Iron Works, HUDDERSFIELD.

HYDRAULIC PRESSES for all purposes.
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SCREW PRESSES of all descriptions.

Textile Stuff and Finishing Presses.
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Steam, Hand, and Belt Driven
High Pressure Pumps.

Press and Pump Leathers of Best Manufacture always on Hand.

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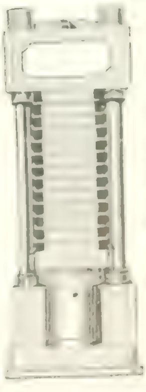
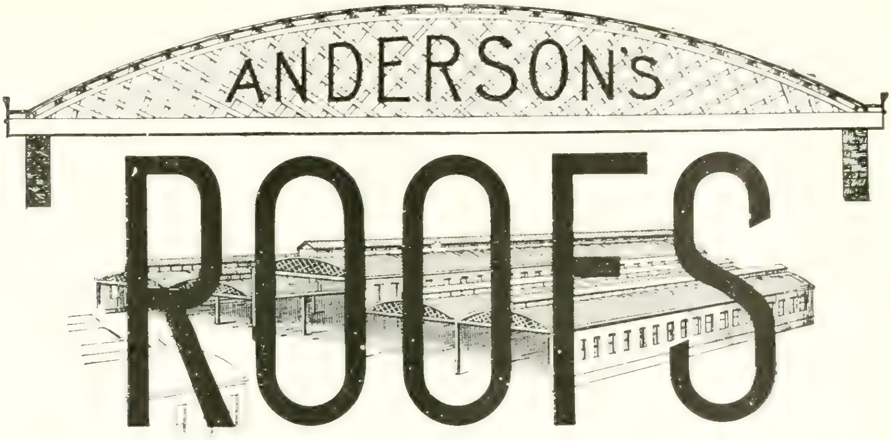


ANDERSON'S

ROOFS



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Buildings for Home and Export.

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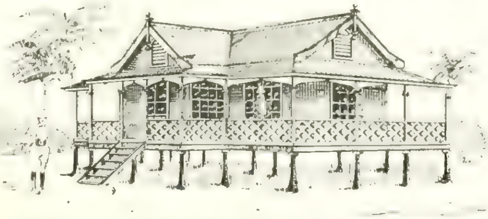

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DELIVERED F.O.B. LIVERPOOL, LONDON, or SOUTHAMPTON.

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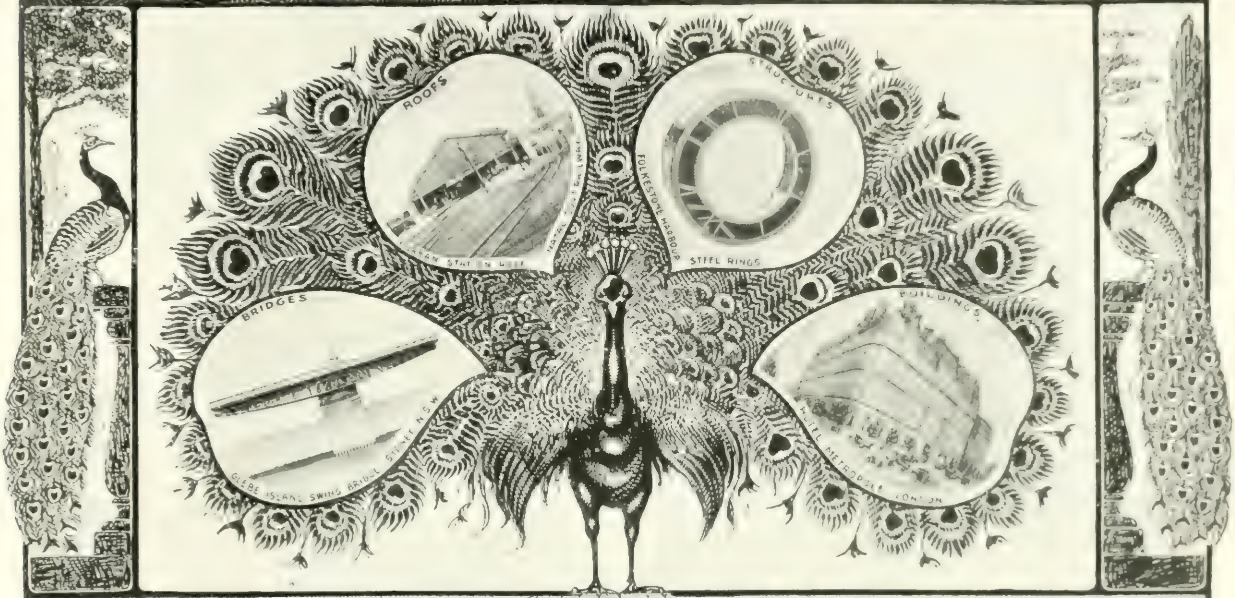

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14, Ct. St. THOMAS APOSTLE

Telegrams:
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"Intersection, London."

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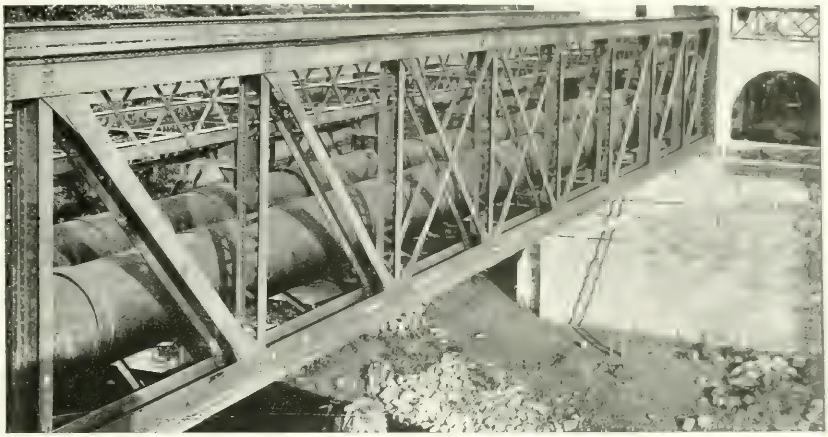

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One Actual TEST is worth 100 Opinions.

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Tests to Destruction Specimens
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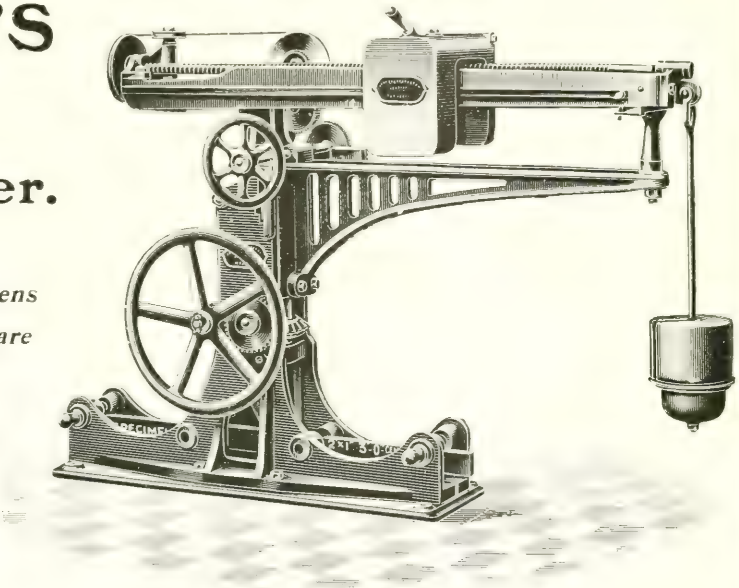

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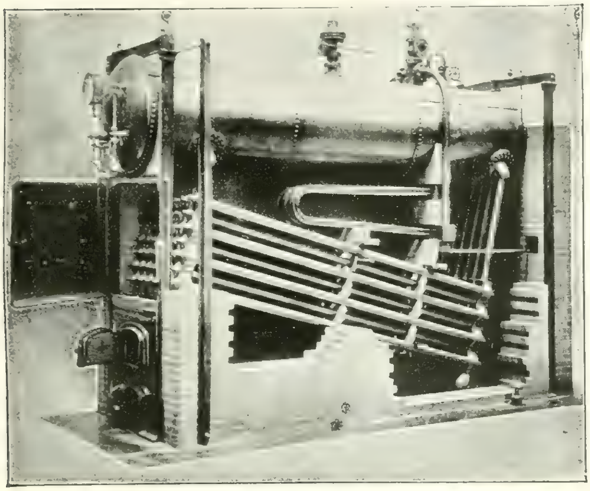

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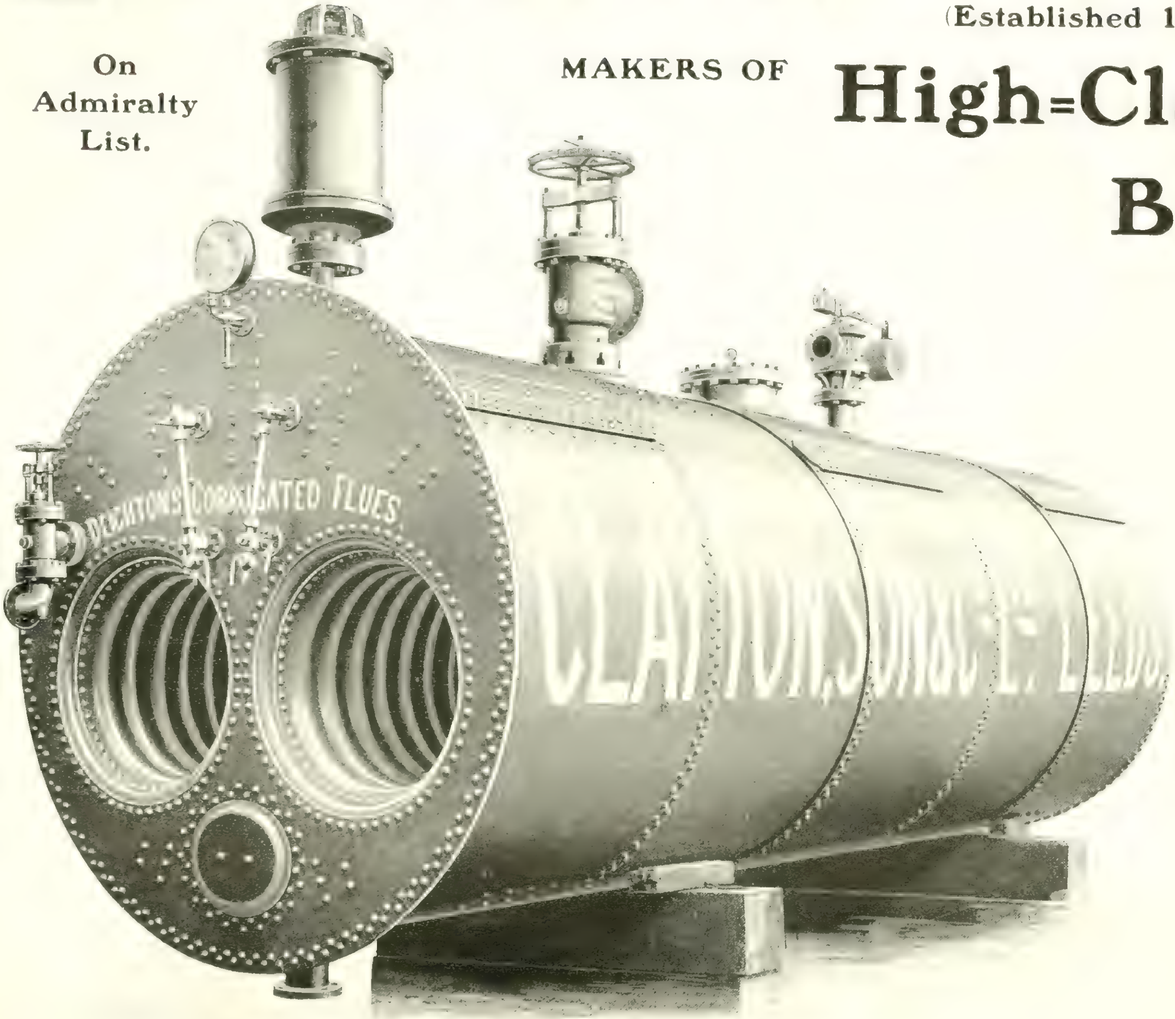

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SPECIALITY.—Boilers fitted with Deighton's Patent Corrugated Flues give 20 per cent. increased heating surface over ordinary flues.

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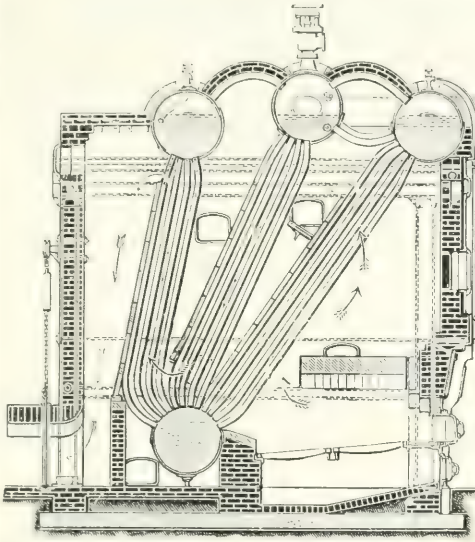

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THE MOST ECONOMICAL BOILER ON THE MARKET.
ADAPTED for ANY KIND of FUEL, and
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THE MORRIN PATENT
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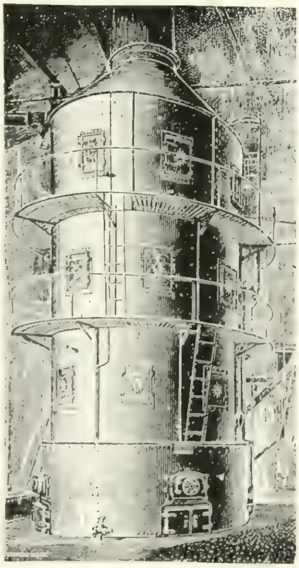

600,000 H.P. in use.
Made in all sizes
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Suitable for all Steam-raising purposes, and all conditions of working.
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Tubes all one size, and expanded into one drum only.
Economical in floor space.
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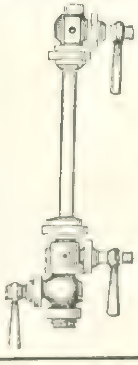

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GAUGE GLASSES,
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PATENT VERTICAL MULTITUBULAR
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Supplied to all the
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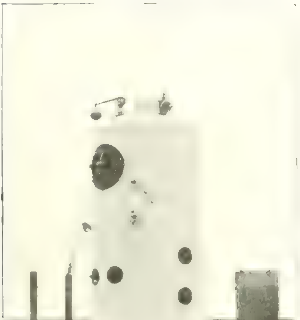
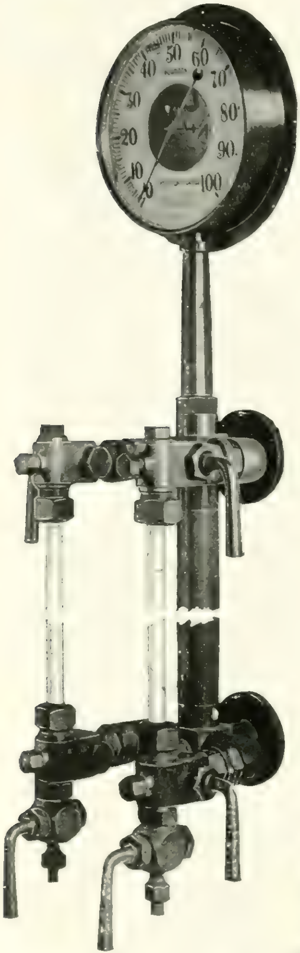
RAILWAY COMPANIES,
and GOVERNMENTS
throughout the World.

COCHRAN & CO. (Annan),
LIMITED,
ANNAN, SCOTLAND.





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Engineers' Brass Finishers.

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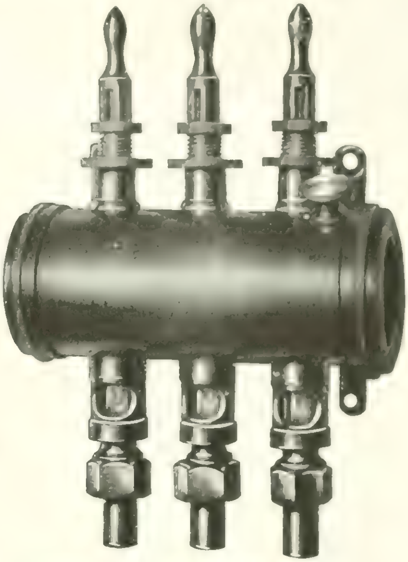
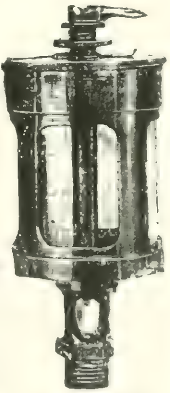


Patent "End Sight" Oil Distributing [illegible]

Telegrams:
MITTON, BIRMINGHAM.
Telephone: 394.



Sight Feed Oil Syphon.

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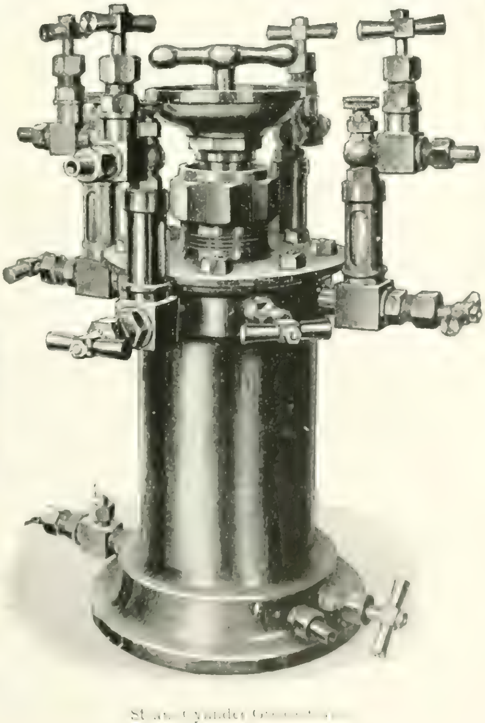

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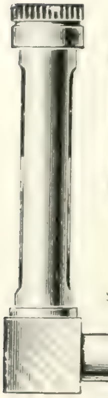

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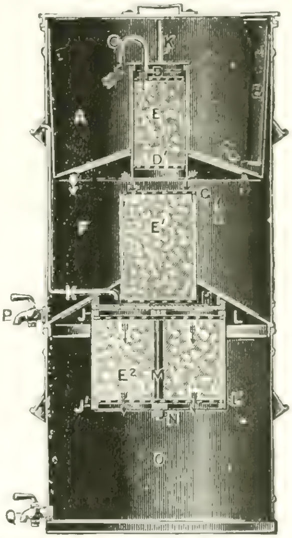

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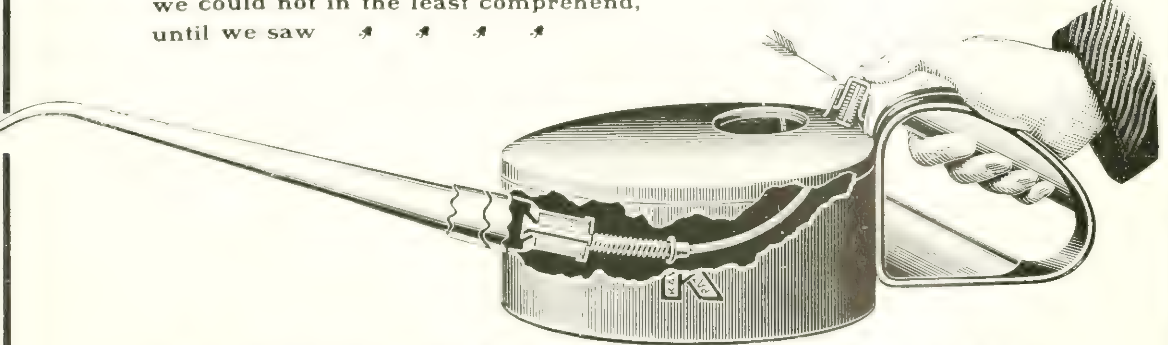

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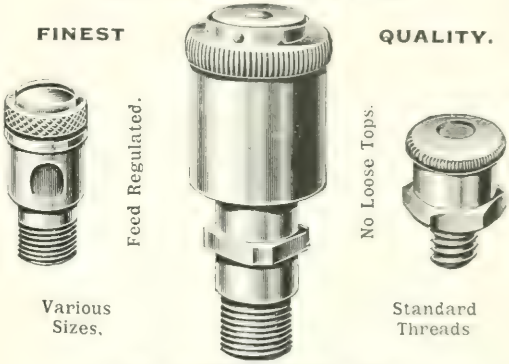

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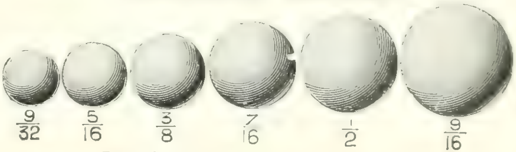

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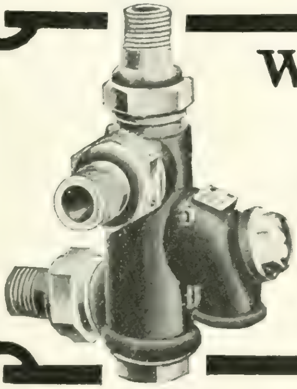

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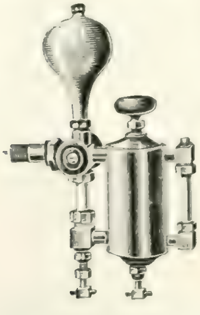

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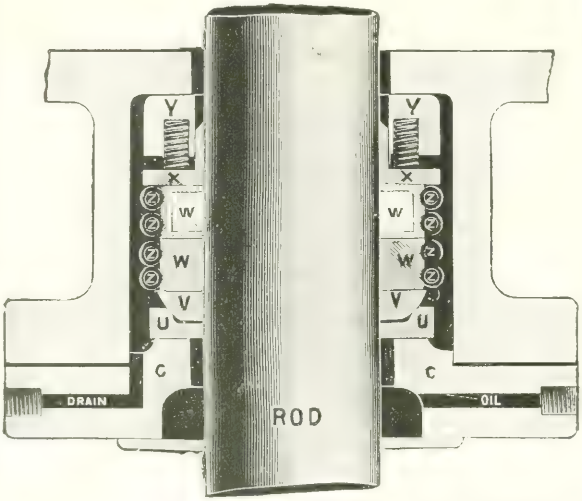

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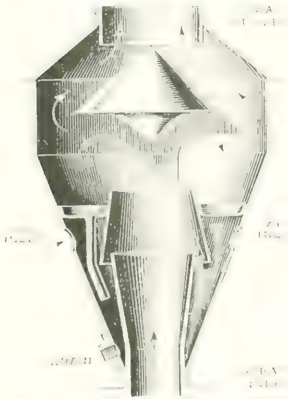

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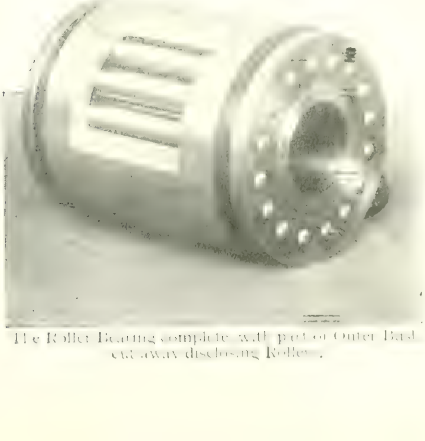

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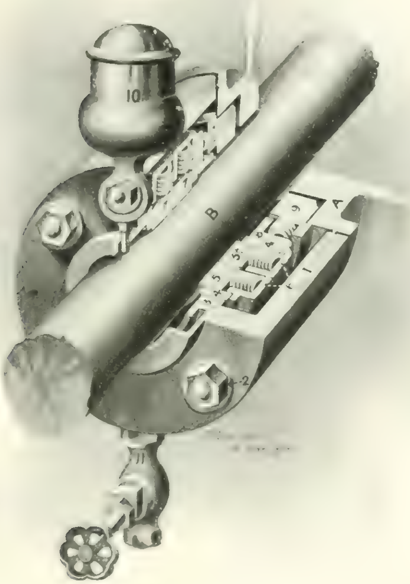

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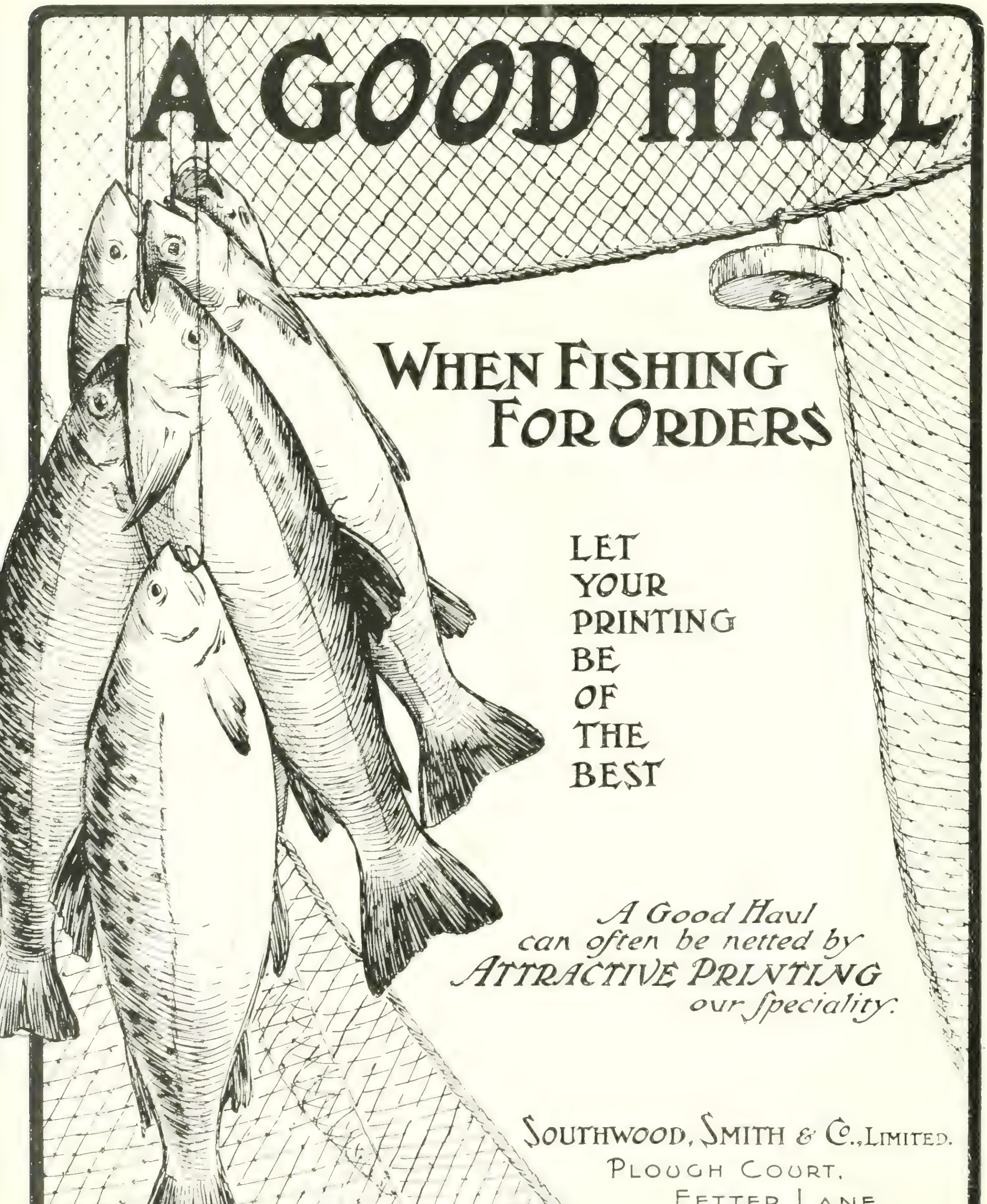

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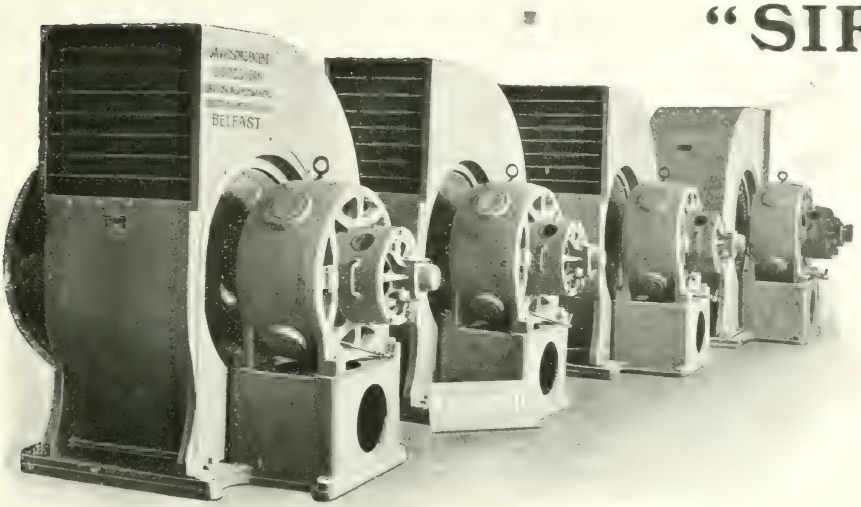

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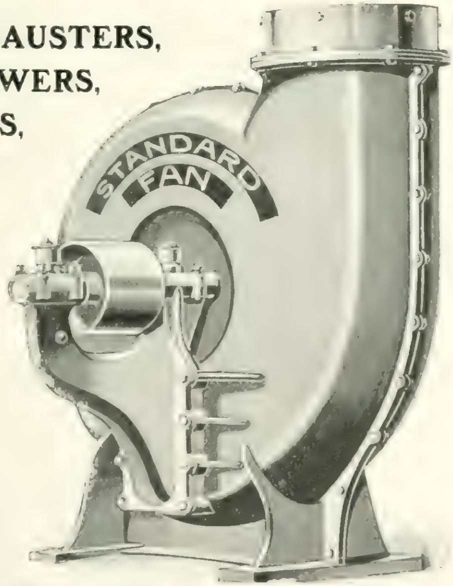

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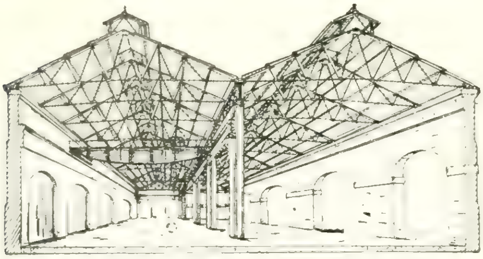

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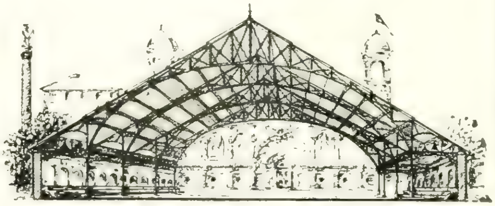

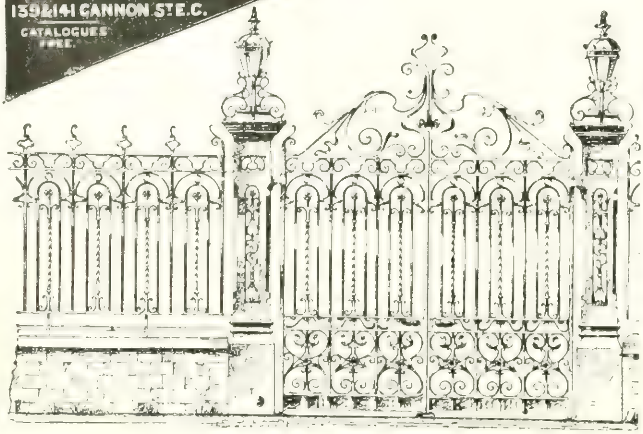

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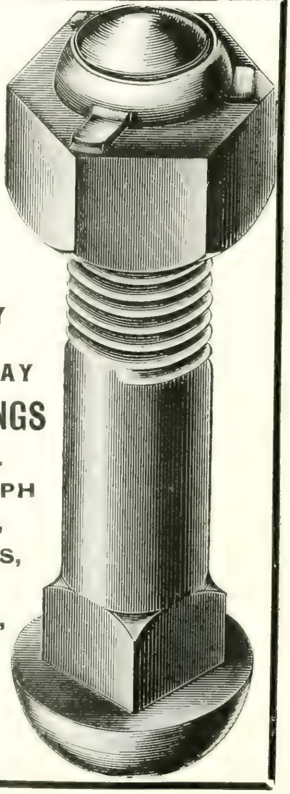

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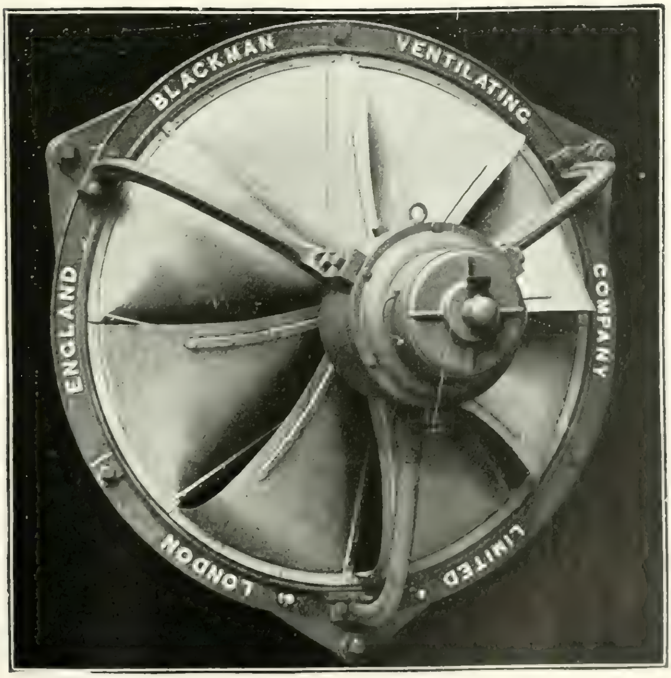

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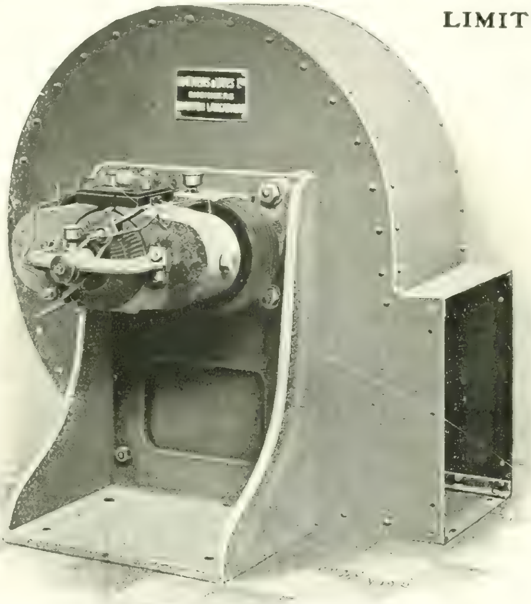

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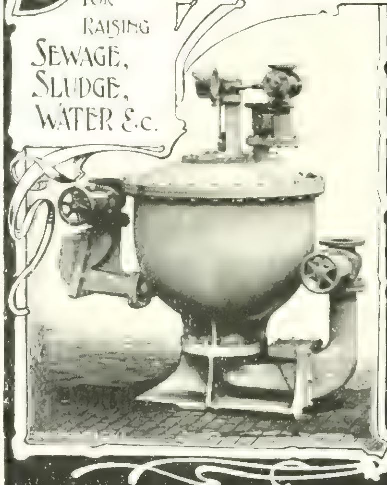

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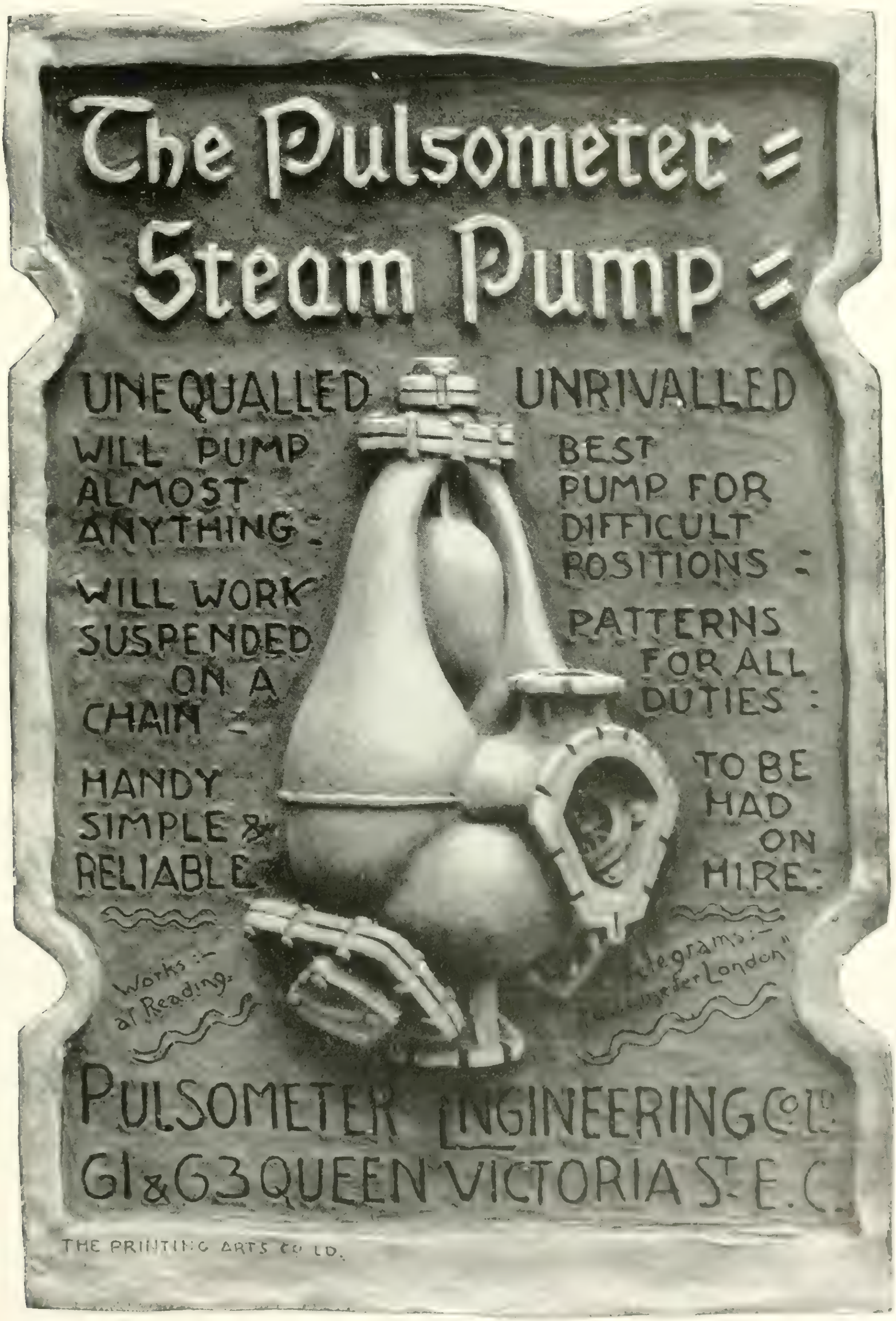

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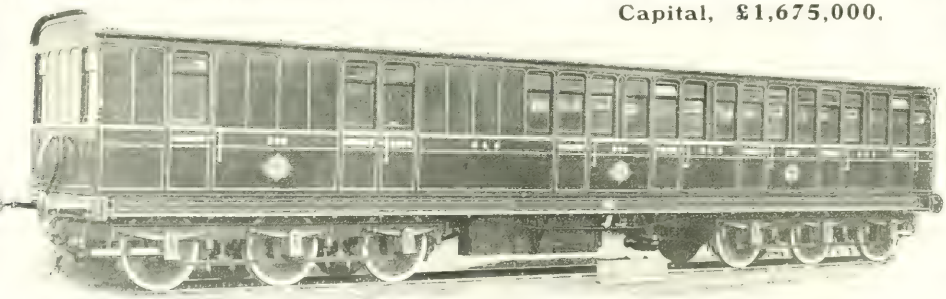

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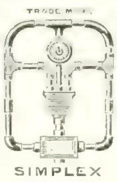

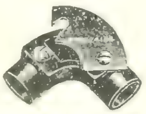

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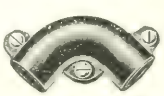

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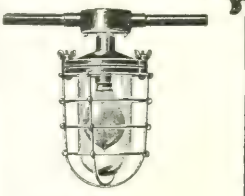

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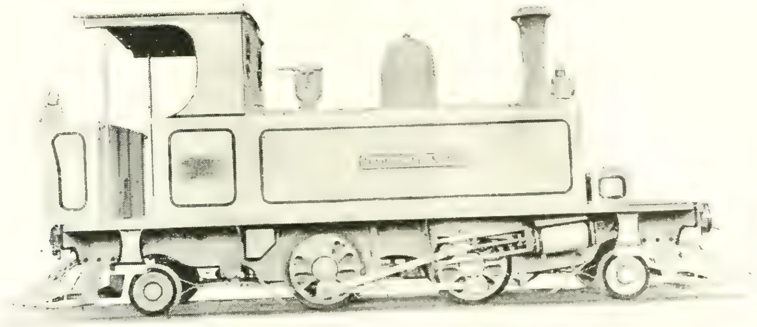

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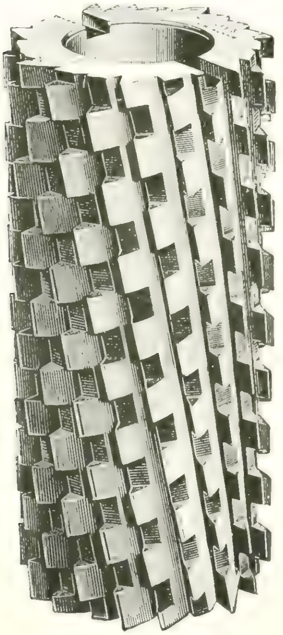

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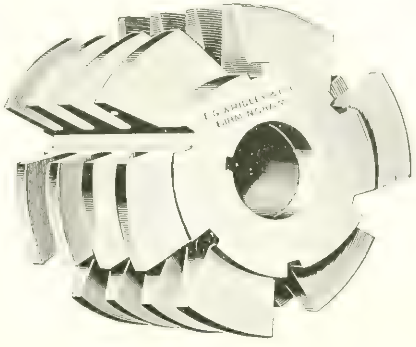

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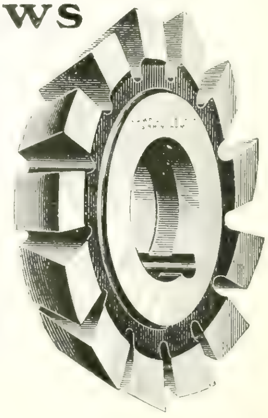

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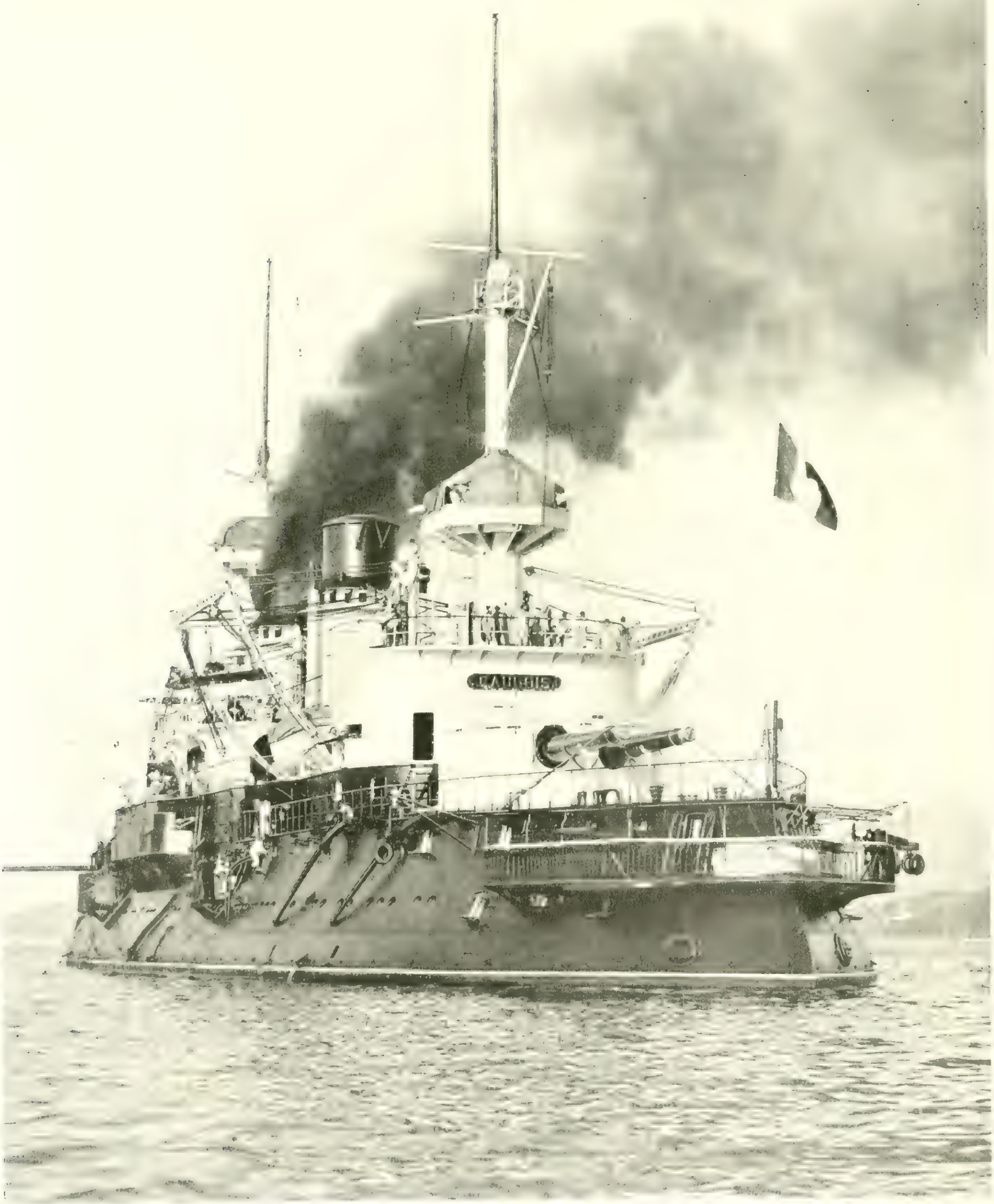

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VOL. II. LONDON, FEBRUARY, 1903. No. 2

Photo by Wm. Gray]

GENERAL VIEW OF BONANZA SURFACE PLANT.

THE EQUIPMENT OF THE BONANZA MINE, JOHANNESBURG.

BY

EDGAR SMART, A.M. Inst. C.E.

This article is the first of a series in which the author will deal with some of the most important gold mining plants on the Rand. He will endeavour to give prominence in each case to those matters in which the plants differ, rather than to well-known features which are common to many mines. Attention will be especially drawn to any improvements in detail of plant or practice which may have been worked out at the particular mine under consideration.—EDITOR.

As it is intended to give descriptions from time to time of the mining and metallurgical plant on some of the leading gold mines of the Rand, it will be as well to say a few words about the general features of the bankets beds, so that the terms which are in everyday use in Johannesburg, such as "deep level" and the like, may be understood in the same way by mining men in other countries where different circumstances have given rise either to other nomenclature, or to different interpretations of the same words. Thus, on the Rand the term "main reef leader" is simply a name given to one of several parallel reefs, and has none of the significance which is given to the word "leader" in quartz mining districts, especially by the sanguine prospector.

The first point is that the owner of a mining claim is limited in his operations by vertical planes passing through his [illegible]

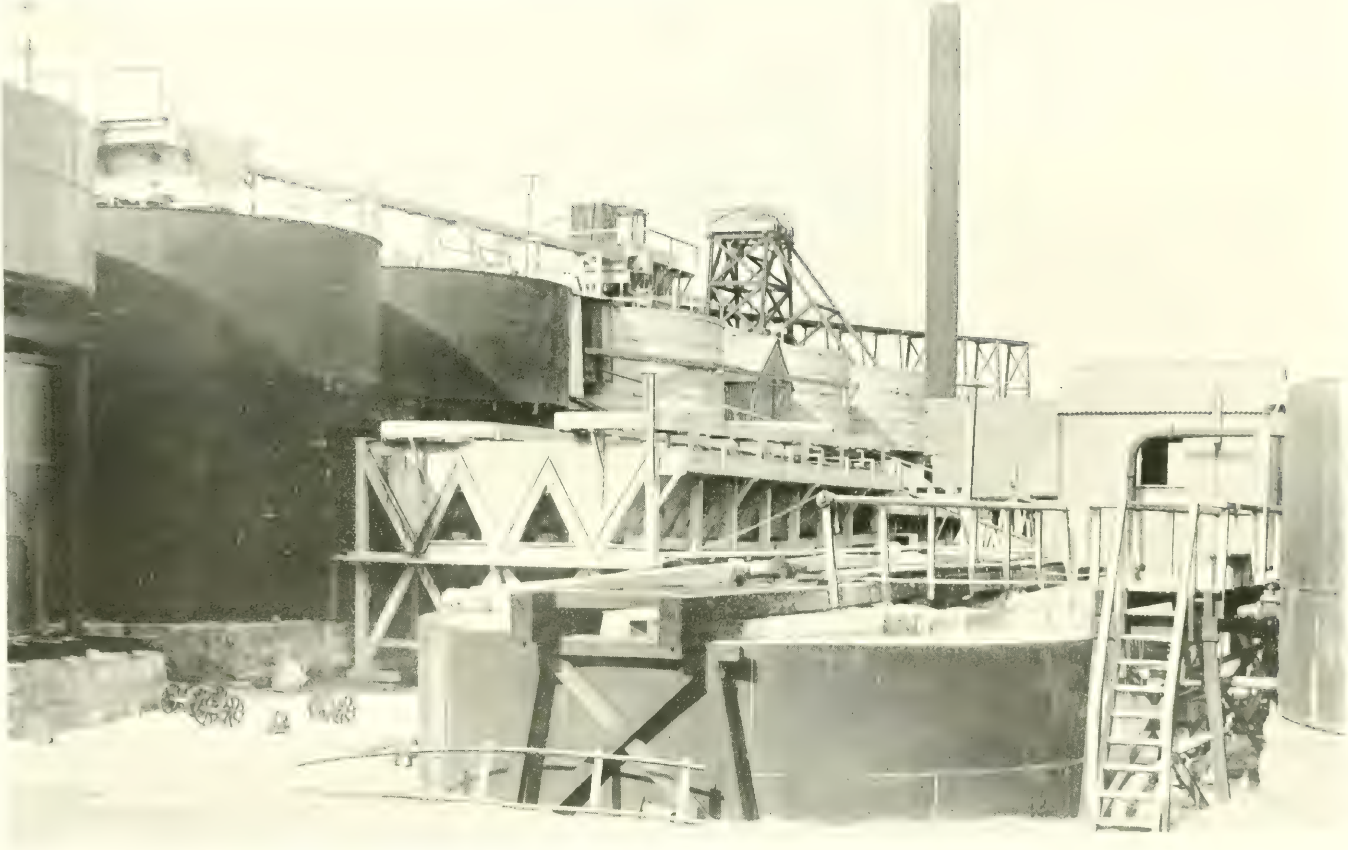
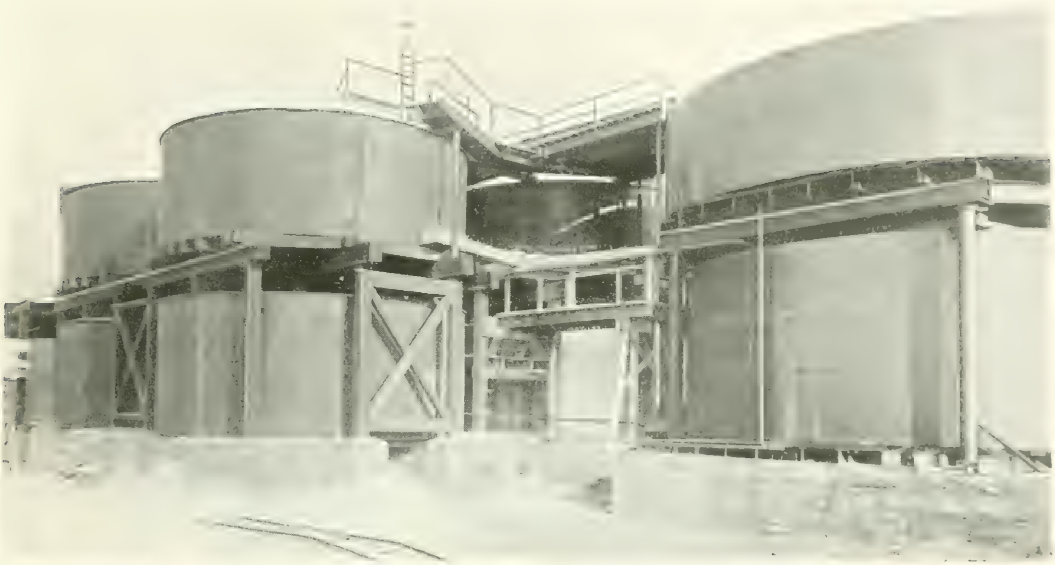


Photo by Author.]

FRONT VIEW OF CYANIDE PLANT AT BONANZA MINE, JOHANNESBURG.

Showing leaching tanks in double tier at the back, the large slime settling spitzkasten in the centre, and part of slimes plant in the right foreground.



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BACK VIEW OF LEACHING VATS, BONANZA CYANIDE PLANT.

Especially showing the construction of the vats and methods of supporting same.

Within these limits he may explore or mine to any possible depth, and thereby not only benefit himself, but also his immediate neighbour on the dip side, into whose claims his reefs must inevitably pass sooner or later, unless they pinch out, or are absolutely vertical on their average course.

The next point requiring notice is that the conglomerate beds of the main reef series, which at their outcrop near Johannesburg have a very considerable inclination of, say, 50 deg. to 80 deg. southwards, have gradually flattened as they go down by continually curving round towards the horizontal.

When the gold was first discovered a long but merely narrow line of claims was pegged out to east and west along the reef, because it was naturally supposed that if the reefs continued downwards the steep angle of inclination would be maintained, so that the space included up to the vertical plane on the south boundary would contain all the reef down to the limiting depth of profitable mining. The properties situated upon this line of claims are known as outcrop mines.

Those who had opportunities for observing the change of inclination of the strata in the outcrop mines, and intelligence enough to profit by the knowledge thus acquired, soon realised that the reefs would pass out of these claims at a very moderate depth, and consequently a second series of claims was pegged out, these additional areas in some cases belonging to the outcrop companies, but in other cases having different owners. The latter areas, when worked separately, are generally known as "first dip" propositions. As further work confirmed the fact that the gold-bearing reefs continued to grow flatter with increasing depth, a number of bore holes were put down at various distances from the outcrop, to ascertain the actual depth of the reefs at these points, and in this way the country for several miles southward has been explored. The properties now being opened up as the result of these boring operations are known as "deep level" mines. Fig. 2, which is a diagrammatic ideal section across the reefs, will assist the above brief explanation. It must be understood, of course, that the actual occurrence of the various beds is not nearly so regular as shown in the diagram, as they sometimes split up into four or more parallel gold-bearing reefs, instead of three.

GENERAL CHARACTERISTICS OF THE MINE.

The Bonanza Mine is situated on the first line of dip, and the work of opening it up was not

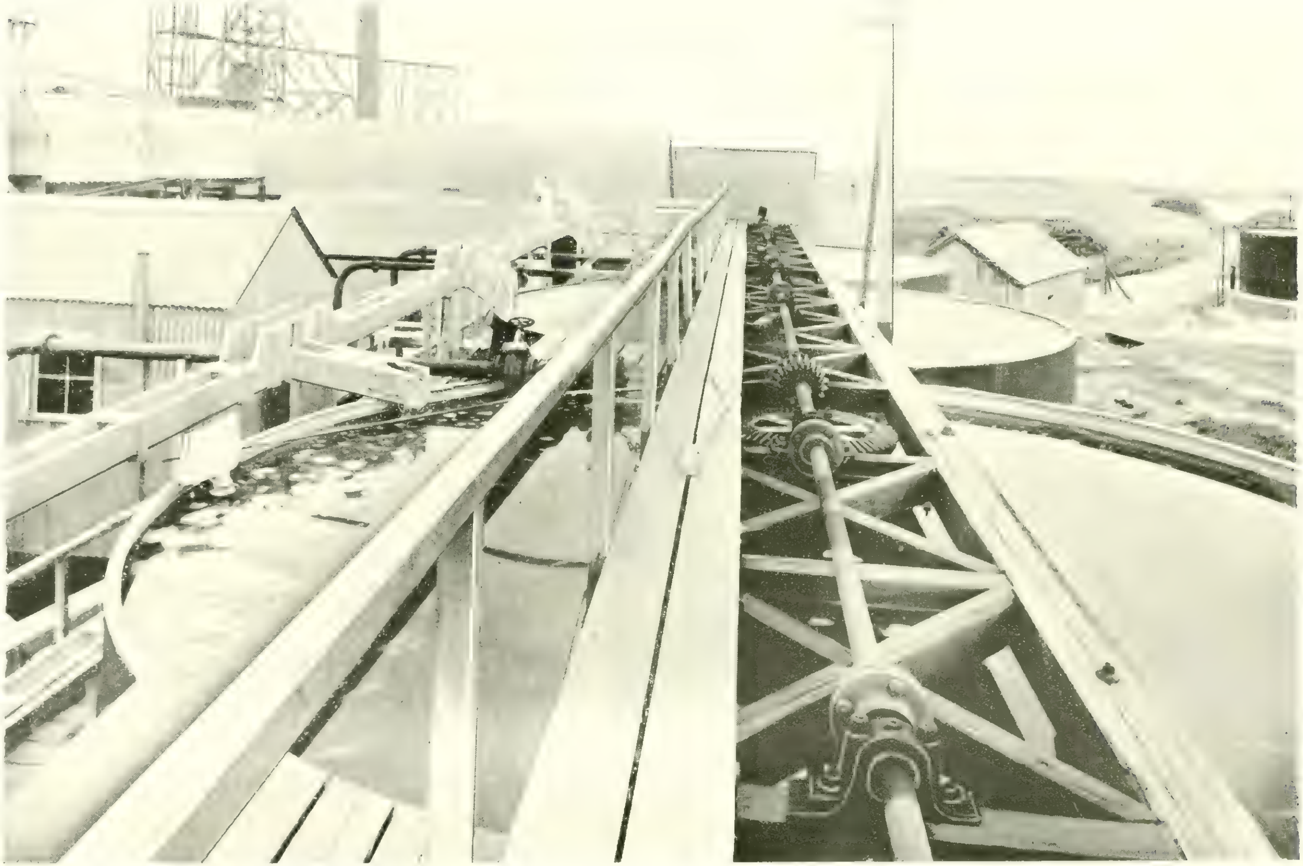


Photo by Author.]

BONANZA SLIME PLANT. TOP VIEW OF UPPER SLIME VATS.

Showing launders for filling same, and gear for driving the stirrers.

commenced until May, 1894. Consequently, the experience as to variation of dip in the reefs, which had been gained in working the outcrop mines, was naturally of great service in laying out the position of the main shaft, and deciding upon the general scheme of development, which has therefore been carried out upon the lines laid down at the beginning of the work by the general manager, Mr. Francis Spencer.

The main shaft is 16 ft. 4 in. by 6 ft. 6 in., clear inside dimensions, and is timbered with 8 in. by 8 in. pitch pine throughout. It is vertical to the depth of 680 ft., and is then turned on an incline of 30 deg., so as to approximately follow the dip of the reefs.

The cost of vertical sinking for a shaft of this size on the Rand, inclusive of timber and timbering, is about £20 per foot.

EXTENSIVE USE OF ROCK DRILLS.

The development of the mine and the raising of the ore are carried on in the usual manner, and need no special reference. One point of interest, however, in the underground work, is the early introduction and extensive use of rock drills in the stopes, instead of drilling by hand with Kaffir labour, under the supervision of white miners, which has been the common practice for stoping even in those mines where rock drills have been largely used for development. The special object of using machine drills in the stopes in this mine is to obtain the ore in large lumps to facilitate the subsequent surface sorting operations; for it is evident that when the rock is broken up into small pieces the sorting becomes more difficult, and with very fine stuff it is impracticable. It has been proved in practice that the extra cost of 2s. per ton for machine drilling is, in this case, more than repaid by the extra profit arising from the more complete sorting.

A very large increase in the number of rock drills used on the Rand may be confidently anticipated, as they will economise labour, and

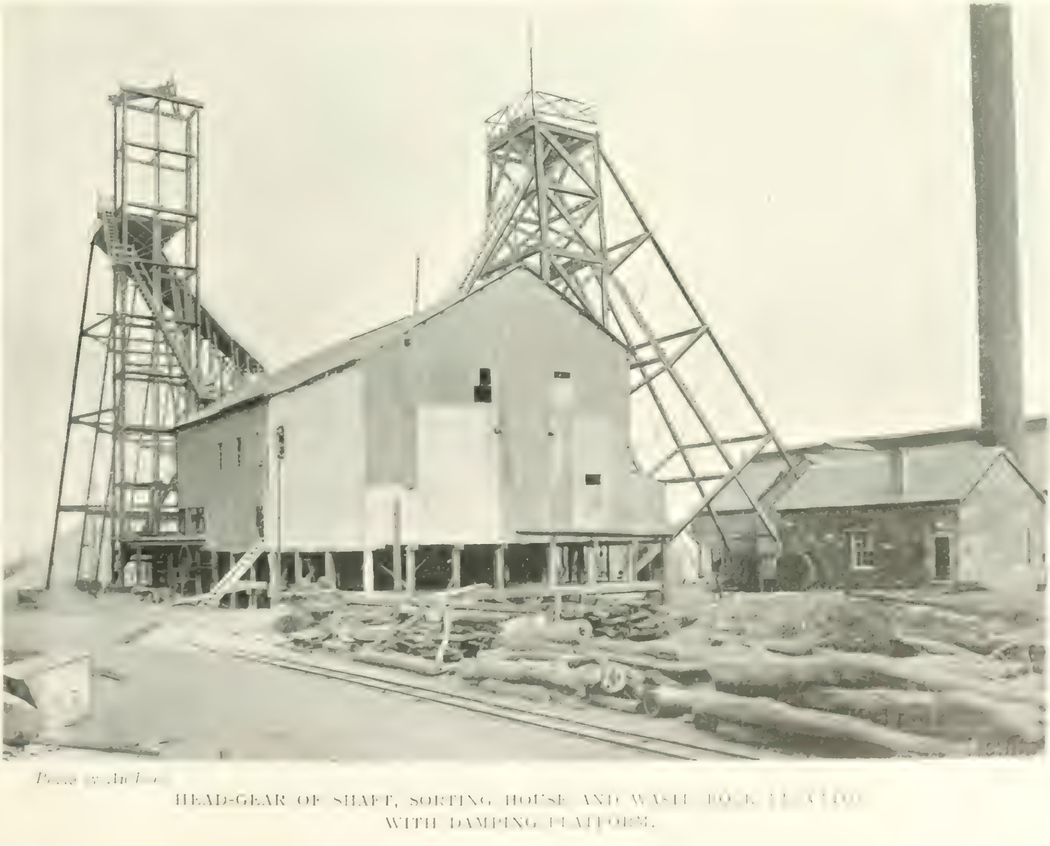


Photo by [illegible]

HEAD-GEAR OF SHAFT, SORTING HOUSE AND WASH ROCK ELEVATOR WITH DAMPING PLATFORMS.

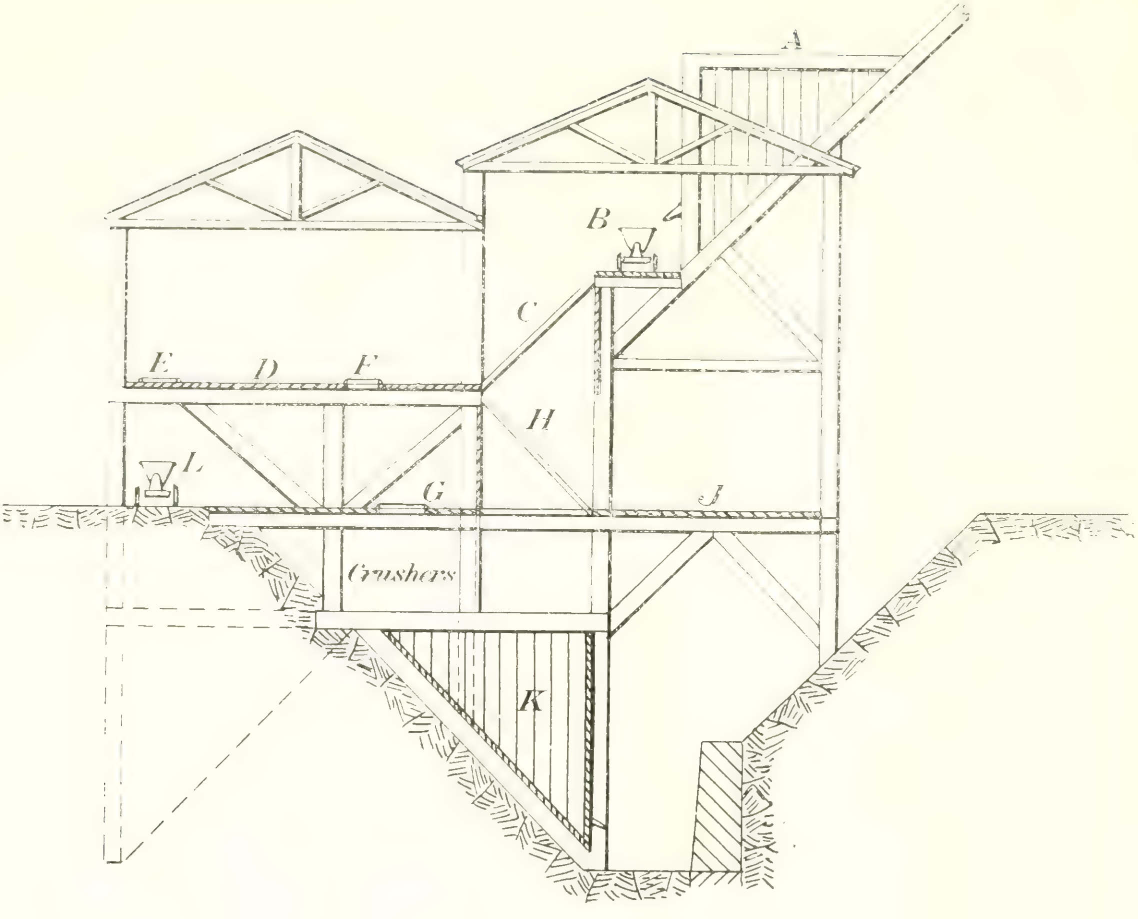


FIG. 1.

obviate to some extent the difficulties which are likely to arise when the shortage of native labour becomes accentuated by the increased number of stamps at work.

The ore is raised in $1\frac{1}{2}$-ton self-dumping skips of the usual type, which deliver it into a bin at the top of the sorting house, shown at A, in fig. 1.

SORTING.

The arrangements for sorting at this mine are interesting, on account of their extreme simplicity. As no revolving table or travelling floor is required, this method may be used with special benefit in cases of limited output, or for mines whose life is likely to be short, so that the introduction of expensive plant is not justified. The ore from the upper bin, A, is filled into trucks, B, which run on a track extending the whole length of the sorting house, along the top edge of the row of four coarse grizzlies, C. The bars of these are set to give $2\frac{1}{2}$ in. spaces, and when a truckful of ore is tipped on to them the largest lumps slide down on to the upper sorting floor, D, where a jet of water is turned on for a few minutes. When washed, the gold-bearing banket is readily distinguishable from the country rock on account of the white quartz pebbles contained in the former. After this brief washing, the lumps of rock are picked up one by one and thrown across the floor by Kaffirs, the waste rock being sent in the direction of the opening, E, while the pay ore is thrown towards the opening, F. Other Kaffirs throw the waste rock into trucks, L, through hole, E, while others send the pay ore down through F to a floor, G, just above the feed level of the gates crushers. These are set to crush the rock to about an inch, after which the broken ore falls directly into storage bins, K.

Returning now to the ore which falls through the first grizzly, C. This falls on to a second grizzly, H, with $1\frac{1}{2}$ in. spaces between the bars, through which the finest stuff falls into the above mentioned storage bins. The medium sized rock slides down to the lower sorting floor, J, where it is dealt with in a similar manner to that already described, after which the payable portion goes through the same Gates crushers as the coarse lumps already mentioned, and to the same storage bins, K.

By this method one white overseer, with twenty-four Kaffirs, can handle twenty tons per hour in a satisfactory manner. The following table gives details of the work done in the sorting department for the first nine months of 1902 :—

Month.	Rock delivered to sorting floors.	Rock sent to waste dump.	Clean ore sent to mill.	Percentage of waste sorted.
	Tons.	Tons.	Tons.	Out.
January ...	9,831	1,959	7,872	19·92
February..	9,772	1,954	7,818	19·99
March ...	10,012	2,100	7,912	20·97
April	9,619	2,242	7,377	23·30
May... ...	10,313	2,206	8,107	21·39
June	9,550	1,770	7,780	18·53
July	9,485	1,636	7,849	17·24
August ...	9,711	1,571	8,140	16·17
September.	9,288	1,680	7,608	18·08
Totals ...	87,581	17,118	70,463	19·55

The principal factors which affect the proportion of waste rock sorted out, and so account for the variations in the last column, are as follow, the first, of course, being obvious :—

1. The width of reef, or more exactly, the proportion between pay ore and mullock across the actual stoping width.

2. The relative quantities of large and small stuff in the broken ore as received from the mine.

WASTE ROCK HOIST AND DUMP.

The trucks from L (fig. 1), containing the waste rock, are taken to the staging near the headgear, shown in the photographs. There they are raised by a Reedy elevator and tipped from the end of the platform, which is about 65 ft. above the ground level, so that a very large quantity of material can be tipped before the dump rises to the level of the platform. When this happens the rails will be extended along the dump, so that this arrangement gives a practically unlimited space for depositing the waste without any alteration of the existing machinery for handling it.

The Reedy elevator stops itself automatically at the end of each journey in a very simple manner. The cages are attached to an endless rope driven by a grooved drum in the usual way. This drum is provided with one driving pulley and two loose pulleys with two belts, one of which is crossed. A light endless wire rope passes over a small pulley at the top of the hoist, and twice round a flanged pulley at the bottom, the latter being connected by sector and rack to the belt forks. Near the top a clamp is attached to this light rope, so that when the cage comes up a projecting lug on the cage strikes

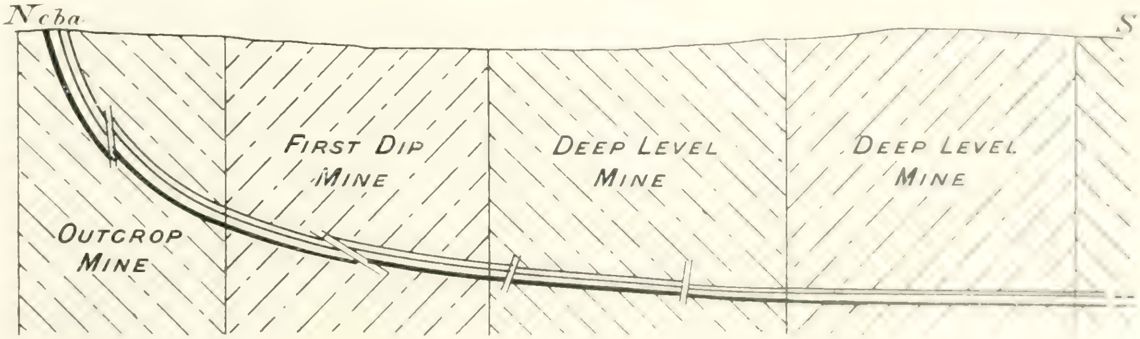


FIG. 2.

the clamp and moves the wire rope far enough to shift the belt on to the loose pulley. To lower the cage again, the rope is pulled still further in the same direction, thus bringing the other belt into action, and giving the elevator drum a reversed motion.

POWER INSTALLATION.

This is of interest, because it includes the electrical transmission of power to several of the separate departments, and also on account of its compact arrangement.

All the steam required for the whole of the works is derived from one set of boilers, each 16 ft. long, and 6 ft. in diameter, of the externally fired return tube type. Four of these are constantly at work, while the remaining two are in reserve, so that all repairs can be effected without interference with the regular running of the machinery. The importance of this will be sufficiently emphasised by a mere statement of the fact that the stoppage of the mill involves a diminution of income equal to about £42 per hour, or say £1,000 per day.

A Weir pump is used for feeding these boilers, and is particularly praised by the company's engineer, Mr. William Gray. This pump is placed in a well, because the feed water is supplied to the boilers at a temperature of about 180 deg. The four working boilers supply steam to the following engines:—

Mill engine, indicating	290	h.p.
Compressor engine, indicating	120	h.p.
Hauling engine, averaging . .	80	h.p.
Total	490	h.p.

The following table, from figures kindly supplied by Mr. Gray, will give a fair idea of the quality of ordinary Transvaal coal.

Table of boiler results for quarter ending September 30th, 1902:—

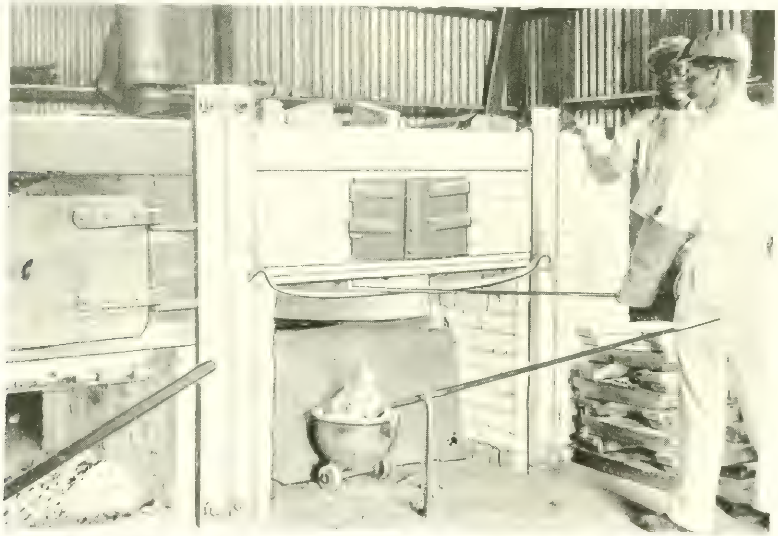


Photo by P. S. [illegible]

CAPELLATION FURNACE USED AT BONANZA MINE.

For new method of refining gold sludge from precipitation boxes using zinc-lead couple.

	Tons of coal	Clinker and ashes in lbs.	Percentage of waste.	Feed water in lbs.	Pounds evaporated per lb. of coal.
July	850	523,875	30·87	8,243,500	4·840
Aug.	850	541,100	31·83	8,753,000	5·148
Sept.	900	601,660	33·42	9,238,100	5·132
	2,600	1,666,635	32·04	26,234,600	5·043

ENGINES.

The hauling is done by a pair of Robey engines, with cylinders of 13 in. diameter and a 26-in. stroke, geared 3 to 1 to a 6-ft. winding drum.

The rock drills are supplied by a cross

compound condensing Ingersoll-Sergeant compressor, with the usual cooling reservoir between the two air cylinders. This machine can, if required, work up to 260 h.p. at fifty revolutions per minute, although at present only about half this power is usually required.

The mill is driven by a Ruston-Proctor compound condensing engine, with 14-in. high-pressure, 24-in. low-pressure cylinder, and 36-in. stroke, running at about seventy revolutions per minute. This engine not only runs the battery, including mill hoist and pump, but also supplies power for the crushers, tailings plant, and workshop by electric transmission from three dynamos, which, together, are capable of delivering 135 e.h.p. to motors distributed about the surface works. This use of electric motors on mines for sub-division of transmitted power is continually extending.

The following table, giving the distribution of power between the various departments during the third quarter of 1902, will be of considerable interest to those having charge of similar machinery elsewhere, but who have not the same facilities for accurate measurement of the separate items. It is simplified in this case by keeping a record of hourly ampère meter readings, a work which amply pays for itself in many ways.

Table showing distribution of power supplied by mill engine for quarter ending September 30th, 1902 :—

	[illegible]		August.		[illegible]	
	I.H.P.	Per cent.	I.H.P.	Per cent.	I.H.P.	Per cent.
Mill hoist ...	[illegible]	[illegible]	0.6	[illegible]	[illegible]	[illegible]
Crushers ...	11·05	3·830	[illegible]	[illegible]	[illegible]	[illegible]
Mill pump ...	10	3·472	10	3·474	[illegible]	3·47
Stamps ...	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tailings pump	8·4	[illegible]	8·4	[illegible]	[illegible]	[illegible]
Sand plant ...	20·42	[illegible]	[illegible]	6·937	[illegible]	[illegible]
Slime plant ...	[illegible]	[illegible]	31·53	10·047	[illegible]	[illegible]
Electric light..	15	[illegible]	15	5·208	15	[illegible]
Workshops ...	3·71	[illegible]	3·6	1·25	3·58	[illegible]

WATER CIRCULATION.

The water supply for the mortar boxes is pumped through the condenser of the mill engine to two storage tanks with a combined capacity of 50,000 gallons. These are placed on a platform about 50 ft. high, so as to command the whole of the surface plant and buildings through hydrants placed at suitable positions around the works. In case of fire a special pump can at once be set to work, which will throw 200 gallons per minute into these tanks. The normal overflow from the tanks goes to the compressor, where it is first used to cool the air in the

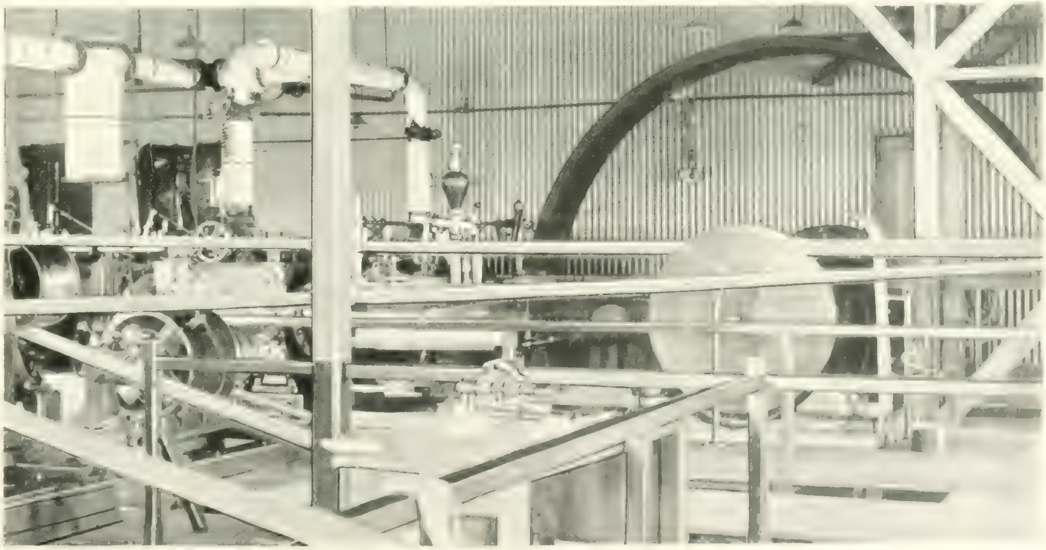


Photo by Author.

MILL ENGINE AND POWER TRANSMISSION DYNAMO — BONANZA MINE.

chamber between the two compression cylinders, and is then passed through the condenser.

The condensed steam from both engines is pumped into a vertical steel cylinder, whose upper half is filled with broken stone, which becomes and remains hot. At the top of the apparatus there is a sprinkler, by which water can be sprayed on to the stones; this water becomes heated as it trickles through to mix with the condensed steam below them. When the feed pump of the boilers draws more water from the cylinder than is supplied by the exhaust steam, a float in the lower half actuates the sprinkler, and the deficiency is made up in the way mentioned above. When, on the other hand, the pump withdraws less than the supply, the surplus passes away by an overflow pipe. By means of this simple apparatus the whole of the feed water is sent into the boilers, as already mentioned, at about 180 deg. F.

THE MILL.

This battery started working in July, 1896, with twenty head; it was increased in October of the same year to thirty stamps, and in May, 1897, to forty stamps, in consequence of the tonnage opened up by the development work having exceeded expectations. In 1900, owing to the reefs in the lower levels proving to be of greater width in the stopes than previously found in the drive, another addition of fifteen stamps was made. The mill now contains forty stamps at 1,050 lb. each, and fifteen at 1,250 lb. each, dropping 7½ in. at ninety-six drops per minute.

At first 20-mesh screens were used, and with these the mill gave a duty of 5·43 tons per stamp per day. In 1897, careful experiment showed that finer crushing would yield a greater total profit, and consequently 30-mesh screens were substituted, with a resultant decrease of duty to 4·98 tons. But another outcome of this change was an increase in the proportion of gold recovered in the mill, which in 1896-7 was 53·54 per cent. of the original value of the ore, while in 1897-8 it was 55·71 per cent. The extractions in the cyanide work were increased from 74·5 to 81·2 per cent. of the gold in the sands, but as there was actually less gold left in the battery tailings during the latter period, the gold recovered by cyanide, calculated on original ore values, was altered from 30·59 to 29·32 per cent., so that the total recovery, before the treatment of slimes commenced, was 85·03 per cent. of the ore value. After the starting of the slime plant in 1897 the mill recovery again increased to 58·42 per cent., this being due to the lime then present in the mill water. In the latest complete record of continuous work for twelve months the figures are :—

Mill recovered	59·81 per cent.
Cyanide from sands and slimes	33·38 per cent.
Total	93·19

The following figures from the company's Annual Report, issued in 1898, show the relative amounts of gold caught inside the mortar box, on the apron plates, and in the riffles at that time :—

Bullion from inside plates	16,859 oz.
Bullion from outside plates	15,395 oz.
Bullion from plate concentrates and mercury traps	30,204 oz.
Total for 12 months' work	62,458 oz.

The ore is brought from the lower bins of the sorting house to the foot of a Reedy elevator in the mill by Kaffirs. It is lifted to the top floor of the mill in the 20-ft. side-tipping trucks and tipped into the battery ore bins, whence it is fed by Challenge feeders to the mortar boxes.

THE TAILINGS PUMP.

In the large majority of mines on the Rand the tailings are lifted from the mill to the collecting vats by internal bucket wheels, but at the Bonanza the pulp leaving the battery is raised to a height of 45 ft. by a double throw plunger pump, 12 in. diameter, with 48 in. stroke. A pipe is connected to the barrel of the pump, so as to provide a small but constant supply of water between barrel and plunger to keep the grit away from the gland. The valves are simply rubber discs resting upon perforated seats, and these seats last for about three months. A second pump has been recently installed, so that repairs can be conveniently effected to pump or gear, without causing loss of time to the mill.

The cost of such a pump erected ready for work is about £875, while a tailings wheel for the same work costs from £1,500 to £2,000, so that two pumps giving the necessary reserve against breakdowns can be put in for the same money as one wheel which is entirely without reserve.

CYANIDE PLANT.

The battery pulp is delivered by the pump just described to a spitzlutte 20 ft. wide. The concentrated underflow from this apparatus is separately collected and partially treated in some of the upper vats shown in the general views of the Bonanza cyanide plant. The other upper vats receive the remainder of the pulp which overflows from the spitzkasten. Each vat has the usual slat-gates for the overflow of slime and water, and the bulk of the battery product is caught in these vats, which are 24 ft. in diameter by 7 ft. deep inside. Both concentrates and sands receive part of their cyanide treatment in the upper vats, and are then transferred to the lower ones, which are of about the same diameter and depth, except in the latest additions, in which case the lower vats have a greater capacity, on account of the greater space occupied by the material after transfer. The overflow from the sand collecting vats goes to a spitzkasten 6 ft. wide, which catches and returns to the pump any fine sand remaining, and leaves practically nothing but slime in the water.

THE SLIMES PLANT.

The slimes are separated by a large spitzkasten seen at page 108, and are carried by the underflow of this apparatus to the slimes plant. This spitzkasten is about 31 ft. wide, 13 ft. long, and 7 ft. deep. The clear water overflow returns to the battery, and is returned direct to the mortars.

There are two rows of slime vats side by side, but at different levels, the upper row being placed at such an elevation that either the pulp or the solution will gravitate from an upper to a lower vat when required, and also that the decant solution will flow to the precipitation boxes from the upper vats, which are used for settling and decantation, while the lower ones are used for pulping and dissolving only. These vats are all 24 ft. in diameter, and 10 ft. and 8 ft. deep respectively. They all have stirrers, which consist of four wooden arms attached to the lower end of a vertical shaft driven by bevel wheels from a line shaft over each row. These vats, with their gearing, are shown in the photo.

GROWTH OF THE CYANIDE WORKS.

These works have been enlarged from time to time to keep pace with the successive increments to the number of stamps, and they are in consequence of this specially interesting from a constructional point of view, as they embody the various forms of construction in vogue at the time when each part was added, while retaining unity of design as regards size and disposition of vats. The variations in the methods of construction are seen in photo at page 109. The original wooden vats are on the left hand side; then there are steel vats on timber staging, and lastly, on the right, both vats and framing are of steel and iron.

As all the more recent double tier plants have been built in this latter style, the following particulars may be useful. The foundations consist of parallel walls of hammer dressed rubble, 2 ft. wide at the top and about 6 ft. high, with a batter of 1 in. per foot on their faces. The walls are 4 ft. apart at the bottom, so as to allow trucks to pass under the vats for discharging the residues. The spaces between the walls are spanned by rolled joists spaced 20 in. apart between centres, and these directly support the lower vats. Cast iron columns about 13 ft. high and of 9 in. diameter are placed on suitable bed stones built into the top of the rubble walls. The columns form an irregular octagon around each vat, and carry the main girders, each of which consists of two 10 in. by 6 in. rolled joists, and these are crossed at right angles by a series of 6 in. by 4 in. rolled joists, spaced 3 ft. between centres, which form the seat for the upper vats.

LIME FEEDER.

An automatic feeding device of an ingenious character, designed by Mr. P. S. Tavener, is used to supply powdered lime to the slime water before this passes to the large spitzkasten. This machine has a hopper for the lime, with two feed screws worked alternately by a rocking frame. The frame carries a water box at one end, which is gradually filled by a small stream of water. When the box is full it pulls over the rocking frame and feeds a small quantity of lime into the slime launder, which passes under the apparatus. When the water chamber runs empty again, a counterweight reverses the rocking frame, thereby bringing the water box back to its first position, while at the same time another feed of lime is given by the second screw. But a very practical point in the feeder is that at each motion of the frame it strikes the hopper, and thereby shakes the lime down to the feed screws, preventing it from sticking together, and so leaving a hollow space above the screws.

REFINING THE CYANIDE GOLD.

The chief point of interest in the treatment department is a method of dealing with the precipitated gold sludge from the zinc-lead precipitation boxes, which has been successfully introduced by Mr. P. S. Tavener, and is likely to be very largely used on other mines in the near future.

The method hitherto employed on most of the mines has been to treat the sludge with sulphuric acid, and then to smelt it in plumbago crucibles with clay liners, using manganese dioxide in the flux to assist the oxidation of the base metals present. By this method some of the silver is also oxidised.

In the process practised at the Bonanza the various sludge and fine zinc products resulting from the clean up of the boxes are separately mixed with suitable proportions of old furnace slag, litharge and assay office slag, and melted down in a reverberatory furnace into lead bullion, carrying about eight per cent. of gold. This bullion is then cupelled in the ordinary manner, and practically the whole of the gold and silver is obtained at once in a saleable form, whereas in the several methods of pot smelting a part of the gold from each clean up has to be recovered from the slag by subsequent operations.

WORKING COSTS.

In comparing the figures given below with those from other mines in the same district, it has to be remembered that this mine is working on a much smaller scale than is usually the case, and the monthly tonnage treated has a great effect upon many of the separate items, especially with regard to labour costs in the several departments and general expenses.

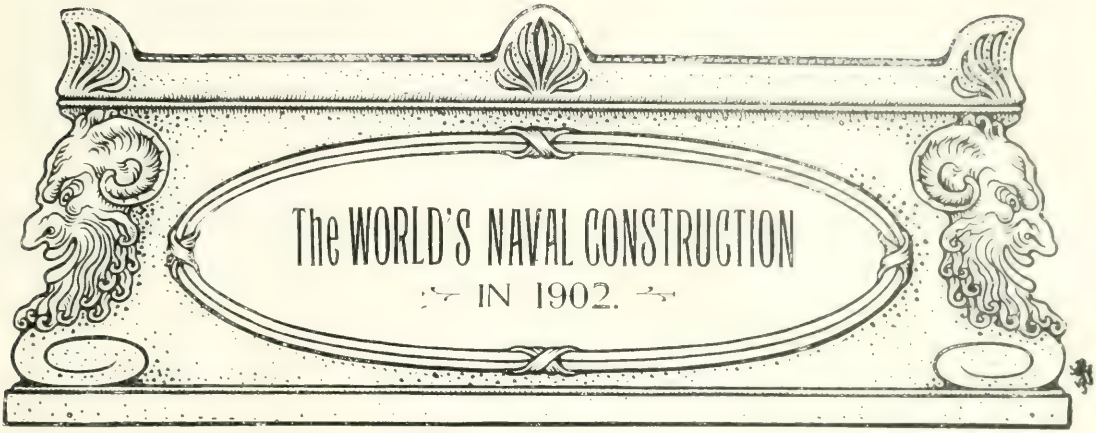
The following table exhibits in a concise form not only the separate costs of the various departments, but also the steady reduction in the total cost which has been effected throughout the whole period during which the mine has been worked. This improvement has been brought about by judicious enlargement of plant when necessary, and the introduction from time to time of better appliances and methods of working.

TABLE OF WORKING COSTS, 1896 TO 1901.

Each item calculated on the basis of tonnage milled. Compiled from annual reports of the Bonanza Company.

	July, 1896, to April, 1897.	May, 1897, to April, 1898.	May, 1898, to April, 1899.	May to October, 1899.	August to December, 1901.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Mining ...	0 14 5	0 12 2·4	0 [illegible] 0·7[illegible]	0 12 8·40	0 14 2·50
Breaking, sorting, and tramming	0 2 0·8	0 2 4·13	0 2 2·24	0 1 8·2[illegible]	0 [illegible] 2·25
Milling	0 4 3·5	0 4 4·17	0 4 7·8	0 3 1·87	0 4 1·20
Cyaniding sands	0 4 8·6	0 4 3·39	0 4 3·20	0 3 4·44	0 3 3·3
Cyaniding slimes		0 [illegible] 1·94	0 2 1·39	0 1 0·80	0 1 4·15
General expenses	0 5 10·7	0 2 0·34	0 1 4·06	0 2 2·75	0 0 0·76
Development redemption	0 6 6	0 7 0·30	0 0 3	0 3 0·45	0 2 0
Machinery expenditure	0 2 0·4		0 0 0·20	0 [illegible] 0·04	0 0 1·22
Total	[illegible]	1 14 5·37	1 13 8·78	1 [illegible] 2·02	1 6 0·25
Profit	3 9 4	3 8 8·[illegible]	3 12 2·23	3 7 3·04	1 14 6·71
Value of extraction	5 2 3	5 2 7·8	5 5 [illegible]	4 18 0·50	3 1 0·06

The increase in this item is chiefly due to the scarcity of efficient labour, upon resumption of operations during the war.



The WORLD'S NAVAL CONSTRUCTION

IN 1902.

BY

N. I. D.

A RETROSPECTIVE view of the naval construction and progress made by the various Powers during the past year shows that, generally speaking, the year's work does not compare well with that of the preceding twelve months, but 1901 was in many respects exceptional, and in this country at all events the large output represented arrears of previous programmes; moreover, the practice now generally observed of laying down ships in batches is conducive to unequal outputs, quite apart from the general progress made. Other causes have been at work. In France, for example, what we may call the vagaries of M. Pelletan have considerably thrown back production, although it would be unfair to put all the blame on the Minister of Marine, since the Chamber failed to make sufficient provision for advancing the three new battleships which it inserted in the programme. Both in Germany and Russia there has been steady progress, each Power completing a certain number of vessels and launching others, while in both cases the projected ships of this year's estimates are important. In the United States something like a year has been lost in discussing the design of the new vessels of the programme of 1902-3. Even now, at the time of writing, the contracts for the cruisers remain unsigned.

Nothing very startling has been reported in connection with the minor navies, but their output has been quite up to the normal. In the tables we give below full information will be found regarding the vessels completed, completing, and laid down during the year.

GREAT BRITAIN.

Five battleships have been completed and commissioned for this country during the past twelve months. These vessels were the *Vengeance*, of the *Canopus* class, commissioned in April; and the *Irresistible*, *Bulwark*, *London*, and *Venerable*, commissioned respectively in February, March, June and November; these vessels belong to the *Formidable* class. Six armoured cruisers have hoisted the pennant; four of the *Cressy* class, namely, the *Aboukir*, *Sutlej*, *Hogue*, and *Bacchante*, commissioned respectively in April, May, the two last in November. In the same month the *Good Hope*, of the *Drake* class, was commissioned. The *Spartiate*, the last of the first class protected cruisers, is also

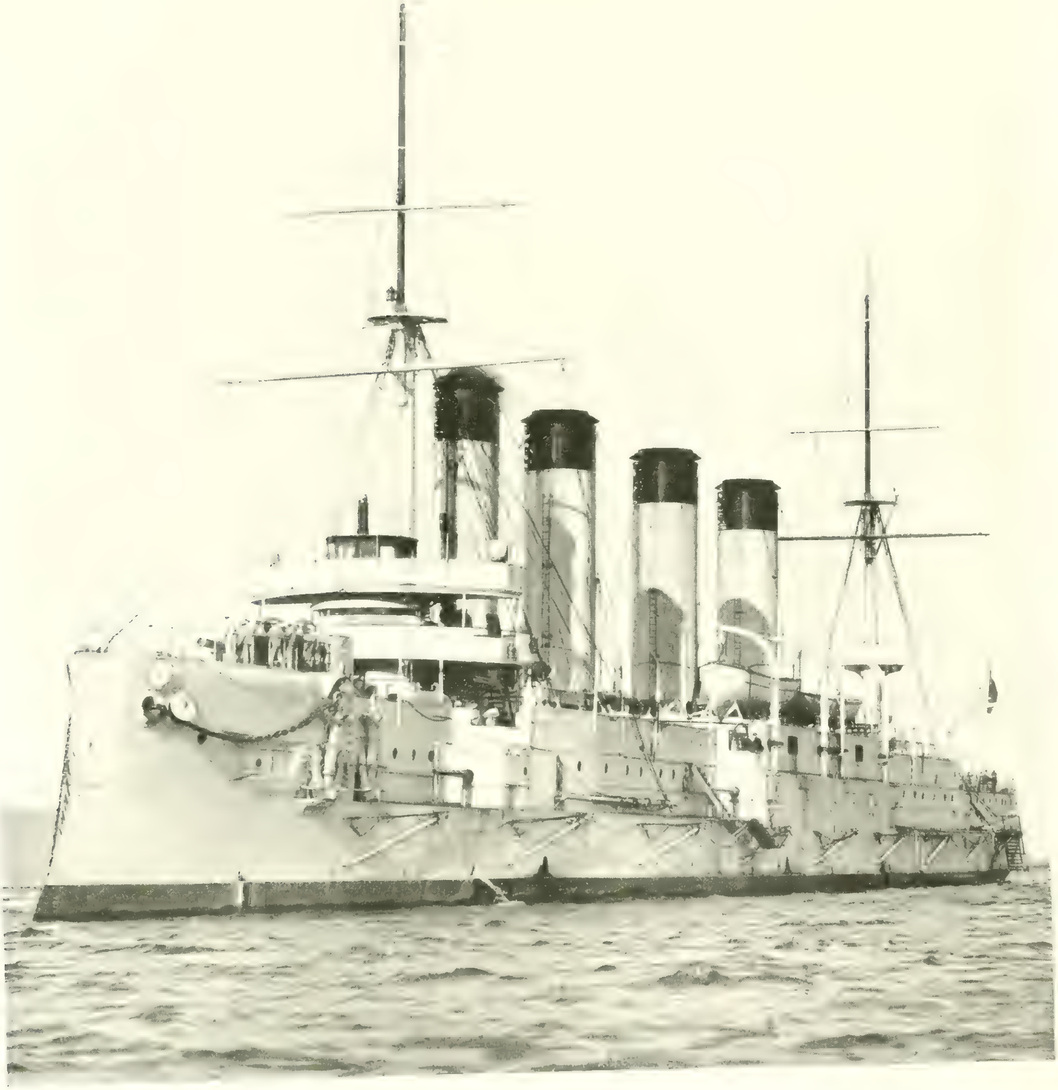


Photo by Marius Bar, Toulon.]

RUSSIAN ARMOURED CRUISER "BAYAN."

Displacement, 7,800 tons; I.H.P., 17,000; Speed, 21 knots. Belleville Boilers. Thickest Armour, 8-in. Krupp steel. Heaviest Guns, 8-in. quick-firers.

ready for commission, and, as regards small craft, the *Fantome* sloop and *Teal* and *Moorhen* gunboats have gone into active service.

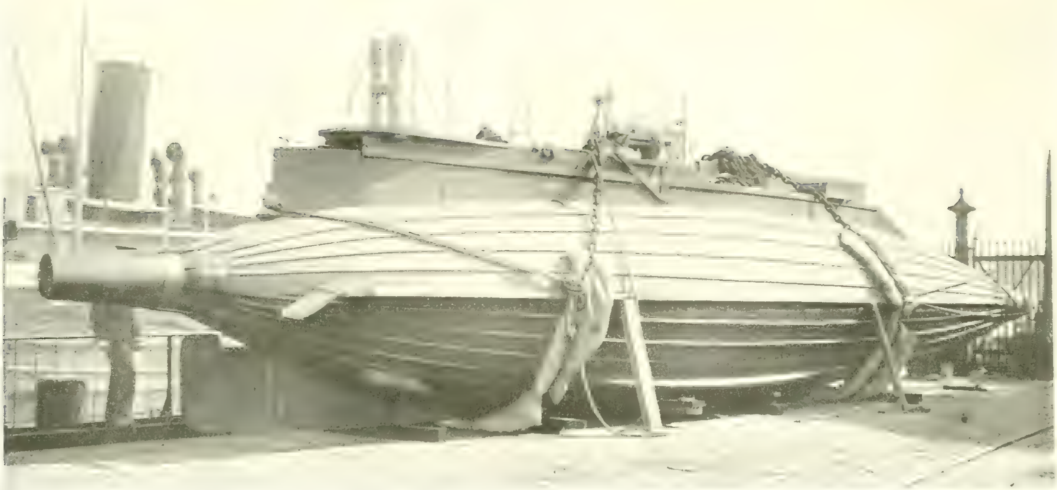
Two battleships, five armoured cruisers, and two protected cruisers have been put afloat during the year, as well as some smaller vessels. The battleships are the *Queen*, launched at Devonport in March, and the *Prince of Wales*, launched at Chatham, in May. The armoured cruisers are the *Cornwall*, launched at Pembroke Dockyard in October; the *Lancaster*, by Messrs. Armstrong, Whitworth and Co., in March; the *Berwick*, by Messrs. Beardmore and Co., in September; the *Donegal*, by the Fairfield Co., in October; and the *Cumberland*, by the London and Glasgow Shipbuilding Co., in December.

The vessels laid down, or to be laid down before the end of the financial year, and those still on the stocks, include five battleships—the *King Edward VII.*, the *Dominion*, the *Commonwealth*, the *Hindustan*, and the *New Zealand;* nine armoured cruisers, four third-class cruisers, two sloops, four scouts, nineteen torpedo-boat destroyers, four torpedo-boats, and three submarines. The armoured cruisers include the *Suffolk*, of the earlier group of "County" vessels, and by the time these notes are in the readers' hands she will probably be afloat, and the battleship *New Zealand* will have taken her place on the stocks at Portsmouth. Then there are the *Devonshire*, *Hampshire*, *Argyll*, *Roxburgh*, *Antrim*, and *Carnarvon*, the second group of "County" vessels, all of them laid down during the year. The remaining armoured cruisers are the *Duke of Edinburgh* and *Black Prince*, of the 1902-3 programme recently ordered.

The third-class cruisers are the *Amethyst*, *Topaz*, *Diamond*, and *Sapphire*, the sloops the *Cadmus* and *Clio*, the scouts the *Sentinel*, *Forward*, *Adventure*, and *Pathfinder*; the torpedo-boat destroyers' names have been recently given in these notes, while the torpedo-boats are numbered 114-117.

There are also in various stages of completion, and some of them nearly ready for

LAUNCH OF THE BATTLESHIP "BRAUNSCHWEIG," AT THE GERMANIA YARD, KIEL.



From *The Navy and Army Illustrated*.

THE LATEST GERMAN SUBMARINE.

Length, 40·213 ft.; Diameter, 6·56 ft. It carries a single torpedo, and at a preliminary trial of three hours remained almost motionless at a depth of two metres beneath the surface.

commission, six battleships, of the *Duncan* class, eight armoured cruisers, two sloops, four torpedo-boats, and four submarines. The armoured cruisers are of three classes; the *Euryalus* belongs to the *Cressy* class, the *Drake*, *Leviathan*, and *King Alfred* are sisters to the *Good Hope*, while of the first group of the "County" vessels there are the *Kent*, *Essex*, *Monmouth*, and *Bedford*.

The total number of vessels at present in hand is thirteen battleships, twenty-two armoured cruisers, six protected cruisers, four sloops, four fleet scouts, nineteen torpedo-boat destroyers, eight torpedo-boats, and seven submarines. The battleships and armoured cruisers are given in the following list:—

BATTLESHIPS.

Name.	Displacement.	Launched.	Where built.
"Vengeance" ...	12,950	1899	Barrow
"Bulwark"	15,000	1899	Devonport
"London"	15,000	1899	Portsmouth
"Venerable"	15,000	1899	Chatham
"Queen"	15,000	1902	Devonport
"Prince of Wales"	15,000	1902	Chatham
"King Edward VII"	16,350	bldg.	Devonport
"Dominion"	16,350	bldg.	Barrow
"Commonwealth"	16,350	bldg.	Fairfield
"New Zealand"	16,350	bldg.	Portsmouth
"Hindustan"	16,350	bldg.	Clydebank

ARMOURED CRUISERS.

Name.	Displacement.	Launched.	Where built.
"Aboukir"	12,000 ...	1900 ...	Fairfield
"Sutlej"	12,000 ...	1899 ...	Clydebank
"Bacchante"	12,000 ...	1901 ...	Clydebank
"Hogue"	12,000 ...	1900 ...	Barrow
"Good Hope"	14,100	1901	Fairfield
"Drake"	14,100 ...	1901 ...	Pembroke
"Lancaster"	9,800 ...	1902 ...	Elswick
"Berwick"	9,800	1902	Beardmore
"Donegal"	9,800 ...	1902 ...	Fairfield
"Cornwall"	9,800 ...	1902 ...	Pembroke
"Cumberland" ...	9,800	1902	L. and G. Co
"Suffolk"	9,800 ...	1903 ...	Portsmouth
"Devonshire" ...	10,800 ...	bldg. ...	Chatham
"Hampshire"	10,800 ...	bldg. ...	Elswick
"Argyll"	10,800 ...	bldg. ...	Greenock
"Roxburgh"	10,800 ...	bldg. ...	L. and G. Co.
"Antrim"	10,800 ...	bldg. ...	Clydebank
"Carnarvon"	10,800 ...	bldg. ...	Beardmore
"Duke of Edinburgh"	13,000 ...	pro. ...	Pembroke
"Black Prince" ...	13,000 ...	pro. ...	Thames

FRANCE.

Three battleships have been completed and commissioned during the past twelve months. These vessels are the *Henri IV.*, the *Jena*, and the *Suffren*. Two armoured cruisers have hoisted the pennant, the *Montcalm* and the *Jeanne d'Arc*, and one protected cruiser, the *Châteaurenault*. One battleship and three armoured cruisers have been launched during the year, the first-named is the *Republique*, and the cruisers are the *Amiral Aube*, *Condé*, and *Kléber*. The vessels laid down, or still on the stocks, are the *Patrie*, *Liberté*, *Justice*, *Vérité* and *Démocratie* battleships, four of which have only just been begun; the armoured cruisers *Jules Ferry*, *Victor Hugo*, *Jules Michelet*, and *Ernest Renan*, of which the last-named is to be re-designed; one protected cruiser, twenty-four destroyers, and twenty submarines. There are also in various stages of completion eight armoured cruisers and a number of small craft. The names of the cruisers are *Leon Gambetta*, *Dupetit Thouars*, *Gueydon*, *Sully*, the *Gloire* and *Marseillaise*, the *Desaix* and the *Dupleix*.

The total number of vessels at present in hand is eight battleships, sixteen armoured cruisers, one protected cruiser, twenty-four destroyers, and twenty submarine boats. The battleships and armoured cruisers are given in the following list :—

BATTLESHIPS.

Name	Displacement.	Launched.	Where built
"Jena"	12,052	1898	Brest
"Republique"	14,865	1902	Brest
"Suffren"	12,728	1899	Brest
"Henri IV."	8,948	1899	Cherbourg
"Liberté"	14,865	bldg.	Contract
"Justice"	14,865	bldg.	La Seyne.
"Vérité"	14,865	bldg.	Contract
"Démocratie"	14,865	bldg.	L'Orient
"Patrie"	14,865	bldg.	La Seyne

ARMOURED CRUISERS.

Name.	Displacement	Launched.	Where built.
"Montcalm"	9,517	1900	La Seyne
"Amiral Aube"	10,000	1902	St. Nazaire
"Condé"	10,000	1902	L'Orient
"Kléber"	7,700	1902	Bordeaux
"Jules Ferry"	12,416	bldg.	Cherbourg
"Leon Gambetta"	12,416	1901	Brest
"Victor Hugo"	12,416	bldg.	Toulon
"Dupetit Thouars"	9,516	1901	Toulon
"Amiral Gueydon"	9,516	1899	L'Orient
"Sully"	[illegible]	1901	La Seyne
"Gloire"	10,000	1900	L'Orient
"Marseillaise"	10,000	1900	Brest
"Desaix"	7,700	1901	St. Nazaire
"Dupleix"	7,700	1900	Rochefort
"Ernest Renan"	12,550	bldg.	St. Nazaire
"Jules Michelet"	12,550	bldg.	L'Orient

GERMANY.

Four battleships have been completed and commissioned, the *Kaiser Karl der Grosse*, *Wittelsbach*, *Wettin*, and *Zähringen;* one armoured cruiser, the *Prinz Heinrich;* and one small gunboat, the *Panther*. One battleship, the *Braunschweig;* two armoured cruisers, the *Prinz Adalbert* and the *Prinz Friederich Carl;* and three small cruisers, the *Frauenlob*, *Arkona*, and *Undine*, of 2,715 tons, have been launched during the year. The vessels remaining under construction, including the *Braunschweig*, are six battleships, the others being the *Mecklenburg* and *Schwaben* of the *Wittelsbach* type, and

JAPANESE PROTECTED CRUISER "[illegible]."

Length, 405 ft.; Displacement, 4,784 tons; I.H.P., 15,500; Speed, 22·5 knots; Thickest Armour, 4½ ins.; Heaviest Guns, 8-in. quick-firers.

three unnamed sisters to the *Braunschweig*. Including the two named above, there are three armoured cruisers in hand, the third being known as the *Ersatz Kaiser*; there are also three coast defence battleships in process of reconstruction, three cruisers, of the *Undine* type, two gunboats, and a number of torpedo craft. Germany has also a submarine in hand.

BATTLESHIPS.

Name.	Displacement.	Launched.	Where built.
"Kaiser Karl der Grosse"	11,130	1899	Hamburg
"Wittelsbach"	12,000	1900	Wilhelmshaven
"Wettin"	12,000	1901	Schichau
"Zähringen"	12,000	1901	Kiel
"Braunschweig" (H)	13,208	1902	Kiel
J	13,208	bldg.	Dantzic
K	13,208	bldg.	Stettin
L	13,208	bldg.	Germania
"Mecklenburg"	12,000	1901	Stettin
"Schwaben"	12,000	1901	Schichau

ARMOURED CRUISERS.

Name.	Displacement.	Launched.	Where built.
"P. Heinrich"	8,868	1900	Kiel
"P. Adalbert"	8,868	1901	Kiel
"P. Friederich Carl (ersatz König Wilhelm)"	8,868	1902	Hamburg
"Ersatz Kaiser"	9,050	bldg.	Kiel

RUSSIA.

Three battleships have been completed and commissioned, the *Rolislas*, the *Pobieda* and *Retvisan*, and five protected cruisers, the *Diana*, *Pallada*, *Novik*, *Boyarin*, and *Bogatyr*, and these vessels, with several destroyers, have been sent to the Far East. Two battleships have been launched during the year, the *Orel* and the *Kniaz Suvaroff*, and one protected cruiser, the *Otchakoff*.

The vessels under construction, in addition to those mentioned, are six battleships, one armoured cruiser, one coast defence battleship, five protected cruisers, and thirty-six destroyers. The battleships and armoured cruisers are given in the following list :—

BATTLESHIPS.

Name.	Displacement.	Launched.	Where built.
"Pobieda"	12,674	1900	St. Petersburg (B)
"Retvisan"	12,700	1900	Philadelphia
"Oslabia"	12,674	1898	St. Petersburg (A)
"Orel"	13,600	1902	St. Petersburg (G)
"Kniaz Suvaroff"	13,600	1902	St. Petersburg (B)
"Slava"	13,600	bldg.	St. Petersburg (B)
"Kniaz Potemkin Tavritchesky"	13,600	1900	Nicolaeff
"Borodina"	13,600	1901	St. Petersburg (A)
"Alexander III Imperator"	13,600	1901	St. Petersburg (B)
"Tsarevitch"	13,110	1901	La Seyne

ARMOURED CRUISER.

Name.	Displacement.	Launched.	Where built.
"Bayan"	7,800	1900	La Seyne

UNITED STATES.

Six battleships have been completed and commissioned, the *Illinois*, *Alabama*, *Wisconsin*, *Maine*, *Missouri* and *Ohio*, but no armoured cruisers have been added to the commissioned list, nor have any battleships or cruisers been launched. One protected cruiser, the *Des Moines*, was put into the water in September, and several small craft have been added to the Navy.

The vessels under construction are battleships *Georgia*, *New Jersey*, *Virginia*, *Rhode Island*, *Nebraska*, *Connecticut* and *Louisiana*, the armoured cruisers, eleven in number, are given in the list below :—

BATTLESHIPS.

Name.	Displacement.	Launched.	Where built.
"Maine"	12,300	1901	Philadelphia
"Illinois"	11,565	1898	Newport News
"Alabama"	11,565	1898	Philadelphia
"Wisconsin"	11,565	1898	San Francisco
"Missouri"	12,300	1901	Newport News
"Ohio"	12,300	1901	San Francisco
"Georgia"	15,320	bldg.	Bath, Me.
"New Jersey"	15,320	bldg.	Quincy, Mass.
"Virginia"	14,948	bldg.	Newport News
"Rhode Island"	14,948	bldg.	Quincy, Mass.
"Nebraska"	15,320	bldg.	Philadelphia
"Connecticut"	16,000	bldg.	New York
"Louisiana"	16,000	bldg.	Newport News

ARMOURED CRUISERS.

Name.	Displacement.	Launched.	Where built.
"California"	13,800	bldg.	San Francisco
"West Virginia"	13,800	bldg.	Newport News
"Pennsylvania"	13,800	bldg.	Seattle
"Colorado"	13,800	bldg.	Philadelphia
"Maryland"	13,800	bldg.	Newport News
"South Dakota"	13,800	bldg.	San Francisco
"Charleston"	9,700	bldg.	Newport News
"Milwaukee"	9,700	bldg.	San Francisco
"St. Louis"	9,700	bldg.	Philadelphia
"Tennessee"		bldg.	
"Washington"		bldg.	

ITALY.

With regard to the other navies, the first in importance is Italy. Although she has not launched any battleships during the past year, and has only sent one armoured cruiser into the water, she has been making much steadier progress with her shipbuilding programme than was expected. The *Benedetto Brin* and the *Regina Margherita*, both of which had been previously launched, have been advanced considerably during 1902, while the *Vittorio Emanuele* and the *Regina Elena* are not yet launched. but should be shortly off the stocks. The three battleships of last year's estimates have been named the *Duca d'Aosta*, *Duca di Genova*, and the *Duca degli Abruzzi*. It is reported that the Italian Naval Budget for 1903-4 provides for the laying down of two more battleships of the *Vittorio Emanuele* type (and it is possible that one of these may be named the *Roma*), two torpedo-boat destroyers, four first-class torpedo-boats, two gun-boats, three submarines, and some auxiliary vessels.

Battleships.

Name.	Displacement.	Launched.	Where built.
"Benedetto Brin"	13,427	1901	Castellamare
"Regina Margherita"	13,427	1901	Spezia
"Vittorio Emanuele"	12,624	bldg.	Castellamare
"Regina Elena"	12,624	bldg.	Spezia
"Duca d'Aosta" (A)	12,624	bldg.	Castellamare
"Duca di Genova" (B)	12,624	bldg.	Spezia
"Duca degli Abruzzi (C)	12,624	bldg.	Venice

Armoured Cruisers.

Name.	Displacement.	Launched.	Where built.
"Francesco Ferrucio"	7,400	1902	Venice

MINOR NAVIES.

The three chief vessels of the Austrian Navy which have been before the public eye during the past twelve months are given in the table below. The *Arpad* is now nearly ready for commissioning; the *Hapsburg* has been under trial with very satisfactory results. and the *Babenberg*. which was launched in the autumn. has been well advanced.

Of the two armoured cruisers which Messrs. Ansaldo have in hand for the Argentine Navy, one, the *Rivadavia*. has been launched. and the other, the *Mariano Moreno*, should be in the water early in the present year.

Chili has bought from Messrs. Armstrong an armoured cruiser, the *Chacabuco*, and a battleship is building by the same firm for this country. It is reported that this vessel will displace 12,000 tons, and that a sister ship is building in the yard of another British firm.

Austria.

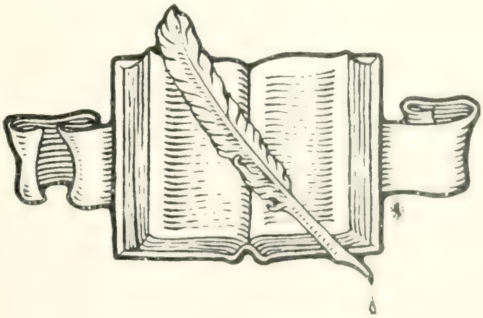
Name.	Displacement.	Launched.	Where built.
"Arpad"	8,300	1901	Trieste
"Babenberg"	8,300	1902	Trieste
"Hapsburg"	8,300	1900	Trieste

Argentine.

Name.	Displacement.	Launched.	Where built.
"Rivadavia"	7,500	1902	Ansaldo
"Moreno"	7,500	bldg.	Ansaldo

Chili.

Name.	Displacement.	Launched.	Where built.
"Chacabuco"	4,300	1901	Armstrong
"Constitucion	12,000	1903	Armstrong
"Libertad"	12,000	1903	Vickers



MILLING MACHINES.

BY

JOSEPH HORNER.

Treats of Plano-Millers, Face-Millers or Rotary-Planers, and some Special Types.

VIII.—(*Concluded.*)

AN ADAPTABLE TYPE OF MACHINE.

Combination types of plano-millers are manufactured to increase their range of usefulness. The Darling and Sellers' machine of this class is excellently designed for heavy work, whether used open-sided, or with the arm supported by the outer upright. The view (fig. 1) will suffice to illustrate its special features. It shows the machine arranged for ordinary work, with the detachable upright in position. This can be removed, leaving the arbor still supported at its outer end by a sliding stay fitting on the arm, and the machine is then ready for open side work, using a horizontal cutter.

The semi-parabolic shape of the arm carrying the arbor stay upon it are good points in this design, superior to the usual methods. The latter generally take the form of a round bar, in the fashion of Lincoln millers, connecting the head and stay, or that of a bracket sliding on, and bolted to, the face of the removable upright. In the Darling and Sellers' design, the alignment of the stay is ensured by sliding it along the arm. As the latter is firmly bolted to the head, clamped to the main standard, and is of the best theoretical form for withstanding the bending stress imposed upon it when used open side, the result is a very rigid structure.

Another point is that there are separate counterbalances for the main head, and the arm with its stay, so that when the arm is removed bodily for open side face milling, the headstock is still perfectly in balance for easy vertical adjustment.

By a special device seen on the front side of the machine, the objectionable and dangerous feature of sudden and very rapid rotation of the large hand adjusting wheels, when the quick power motion to the table is set in operation, is absolutely prevented. The hand wheel in question is clutched to its shaft, and the clutch can only be engaged when the belt operation lever of the power motion is in its central, or idle, position.

The gears are all protected with hoods, and the controlling handles are brought to the front side within easy reach of the operator. The graceful outlines by which the very substantial build of the machine is somewhat masked are noticeable, as is also the great proportion of depth to width of the bed. The machine, which weighs 5 tons, is capable of milling a length of 7 ft., it will clear 1 ft. 8 in. between standards, and a depth of 1 ft. 6 in. under the cutters, which are 4 in. in diameter. The cross slide will permit of a cutter up to 10 in. diameter clearing under it. The cutter arbor measures $2\frac{1}{4}$ in. diameter. The feed can be varied from $\frac{3}{8}$ in. to 6 in. per minute.

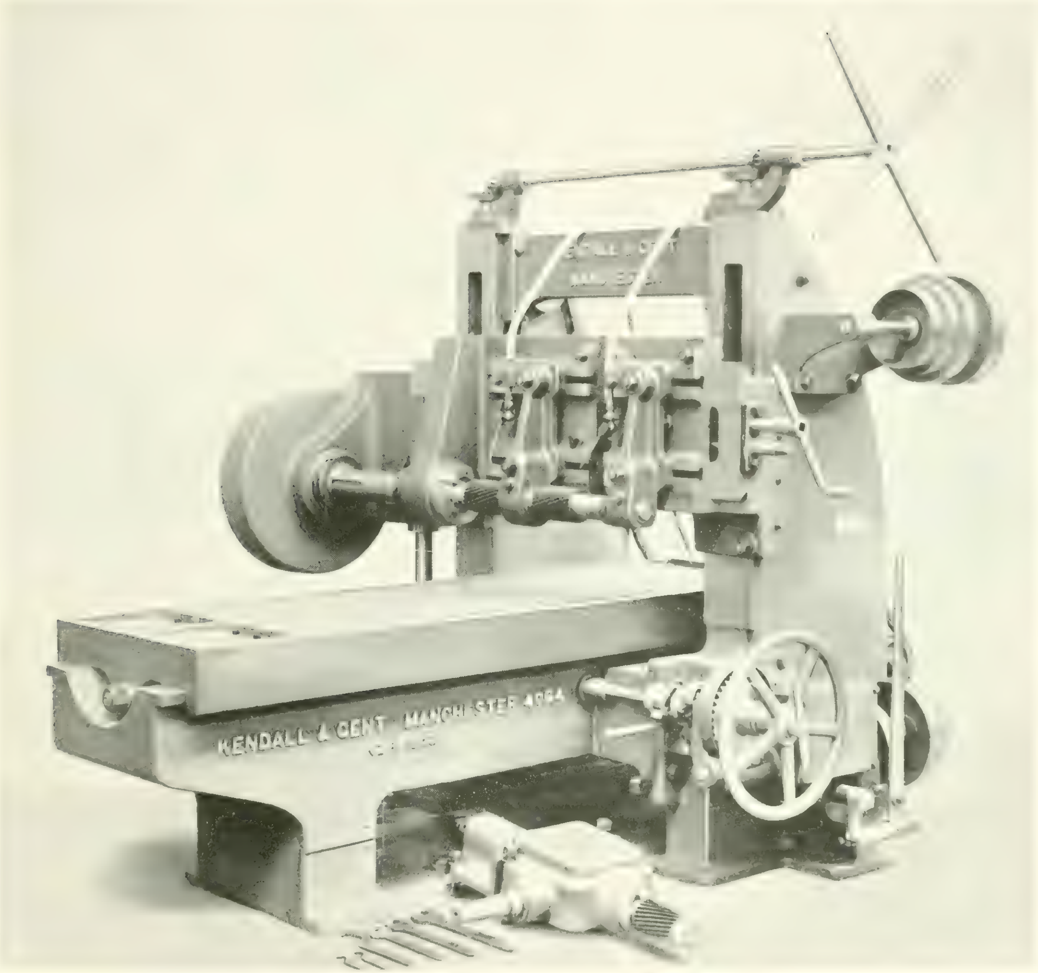


FIG. 2. HORIZONTAL PLANO-MILLING MACHINE.
KENDALL AND GENT, MANCHESTER.

THE CUNLIFFE AND CROOM PLANO-MILLER.

Messrs. Cunliffe and Croom, Ltd., make a small plano-miller admitting 24 in. between the uprights. It is a stiff little machine on standards, and the spindle driving gear is exceptionally large. The spindle has a lateral adjustment which enables the cutters to be put into position after the work has been fixed on the table. The table drive is through worm gear, and a screw with a disengaging clutch. There is an automatic disengaging motion, and a quick return by-power by means of fast and loose pulleys, and mitre gears at the end of the screw at the back of the machine.

MACHINES BY KENDALL AND GENT.

A machine by Messrs. Kendall and Gent, of Manchester, is shown in fig. 2, being a plano-miller with horizontal spindle. This particular example is the smallest size made in this type by the firm, the length which can be milled being 6 ft. It is of solid build, weighing 135 cwts. Its substantial character renders it specially suitable for the work of the locomotive and marine engineers, besides that of a general class. Milling the flat sides of links, the webs of levers valve and coupling rods, is generally more economical than planing them Narrow edges are milled in quantity by arranging the pieces

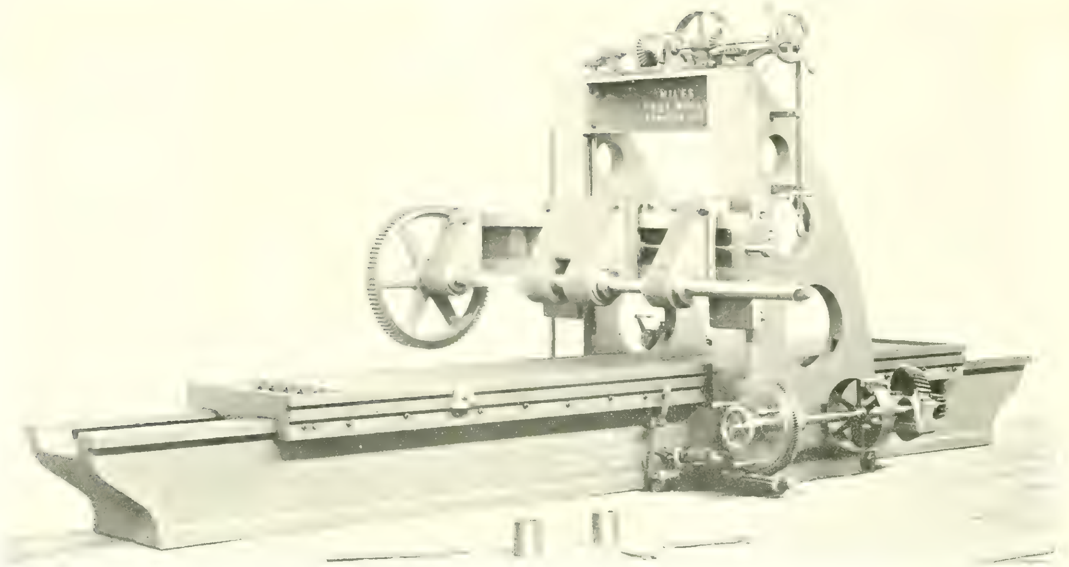


FIG. 3. HEAVY SLABBING MACHINE.
NILES-BEMENT POND CO., LONDON AND U.S.A.

side by side, and using a broad cutter wide enough to cover the lot.

The machine is so designed that a gang of cutters can be used to operate on work as wide as the table at one traverse. The two adjustable brackets on the cross slide permit of variation in the length of cutter arbors, and afford them ample support at the intermediate position, as well as at the end. A three-speed cone pulley, with back gears provides six speeds to the spindle. The cross slide is raised and lowered by the cross handle, in planing machine fashion, and is counterbalanced, portions of the supporting pitch chains being seen behind. There are six feeds to the table, which is screw driven. The rates of feed are read off on an index pulley. A vertical spindle attachment—seen on the ground—fits on the cross slide, to be used for edge milling.

AMERICAN DESIGNS.

American designs are numerous in this type of machine. Illustrations (figs. 3 and 4) of the productions of the amalgamated Niles-Bement Pond Company are given. Another firm making a speciality of these heavy types is that of Beaman and Smith, of Providence, R.I. These are manufactured with spindles ranging in number from one to four. Some have two housings, some are open-sided, others have one housing, removable at pleasure.

A favourite form of open-side machine by this firm is that in which an upright is bolted to one side of the bed. Upon it slides the overhanging arm, its vertical adjustment being provided by a screw which is supported on a ball bearing. A saddle has horizontal movement along the arm, automatically fed in or out with a stop for each direction of movement. The spindle is carried in a head, adjustable vertically. The driving power is derived from a four-stepped cone through back gear, providing six cutter speeds—from 10 to 114 revolutions per minute—suitable for cutters ranging from 12 in. to 1 in. diameter. The table feed, which is screw driven, ranges from 1 in. to 8 in. per minute, for any speed of the spindle. The feed of the saddle which carries the spindle head is from about $\frac{1}{2}$ in. to 4 in. per minute.

Another open-side machine carries two vertical spindles, each with independent vertical and cross adjustments. The arm has vertical adjustment by a screw with a graduated dial. In other cases the overhanging end is supported on a bracket, or housing.

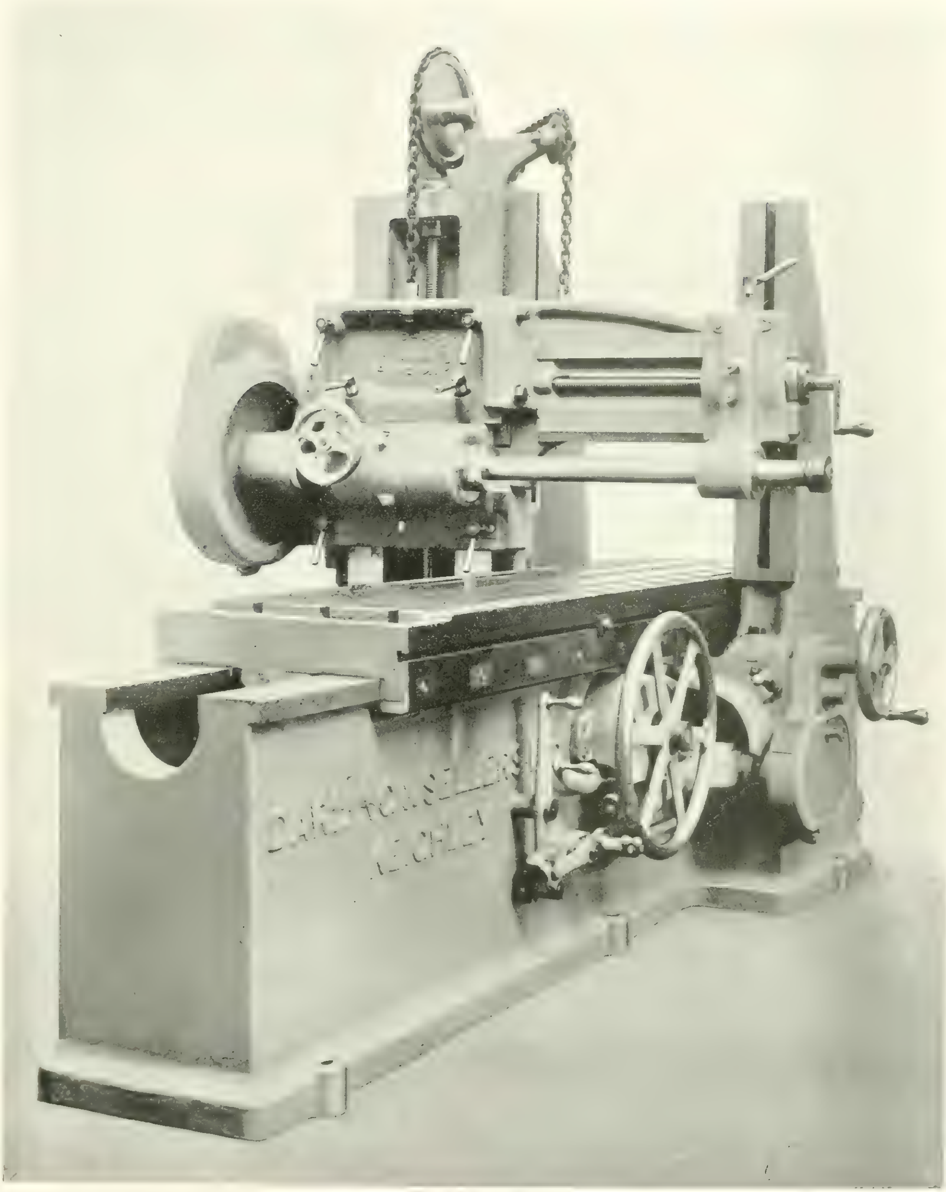


FIG. I. PLANO-MILLER, WITH OUTER STANDARD AND STAY IN POSITION

DARLING AND SELLERS, LTD., KEIGHLEY.

A MACHINE THAT MILLS EIGHT FACES SIMULTANEOUSLY.

A very special milling machine is illustrated in fig. 5, by Messrs. John Hetherington and Sons, Ltd., of Manchester, designed for the London and North-Western Railway Co., for finishing at one operation eight faces on the quadrants, one of which is seen on the ground. It will be observed that one of the heads is carried on a hinged swinging bracket, which is thrown open, as seen in the illustration, when the work is being inserted. The quadrant to be tooled is gripped in a chuck on the rising and falling table, this motion being imparted for the feed. The act of closing up the swinging front brings the bevel wheels into gear, so that all the cutters operate at once. The self-acting feed being also put in the casing is fed against the cutters.

The advantage which such a machine possesses over a planer, shaper or slotter, lies not only in the fact that so many faces are being tooled simultaneously, but also in the uniform size and shape of all the castings operated on.

MILLING ON A PLANER.

Not much has been done as yet in adding milling appliances to other machines, though various machines are designed to combine milling with drilling, boring, or turning. The Adams Company, of Dubuque, Iowa, have a

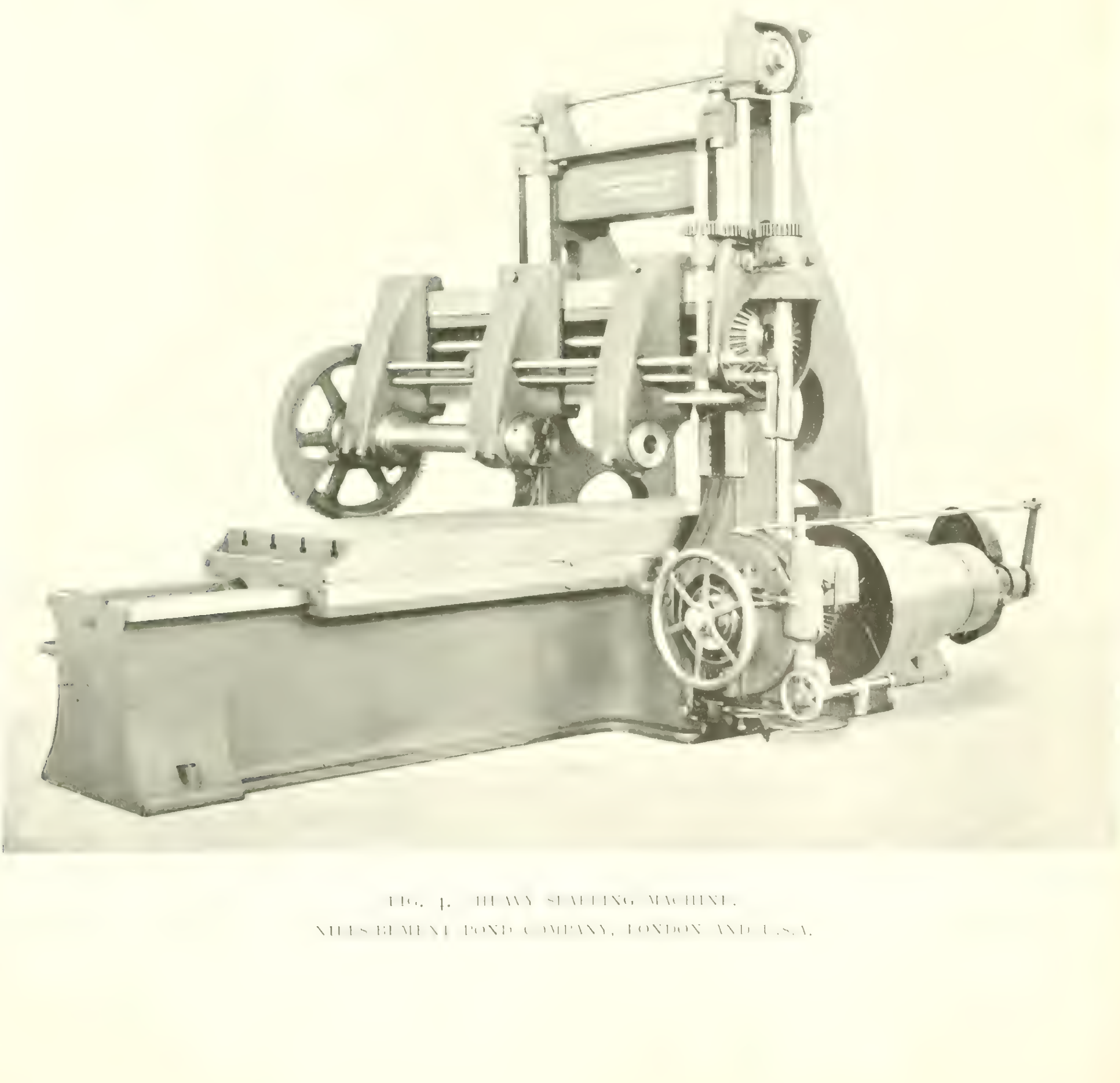


FIG. 4. HEAVY SLABBING MACHINE.
NILES-BEMENT-POND COMPANY, LONDON AND U.S.A.

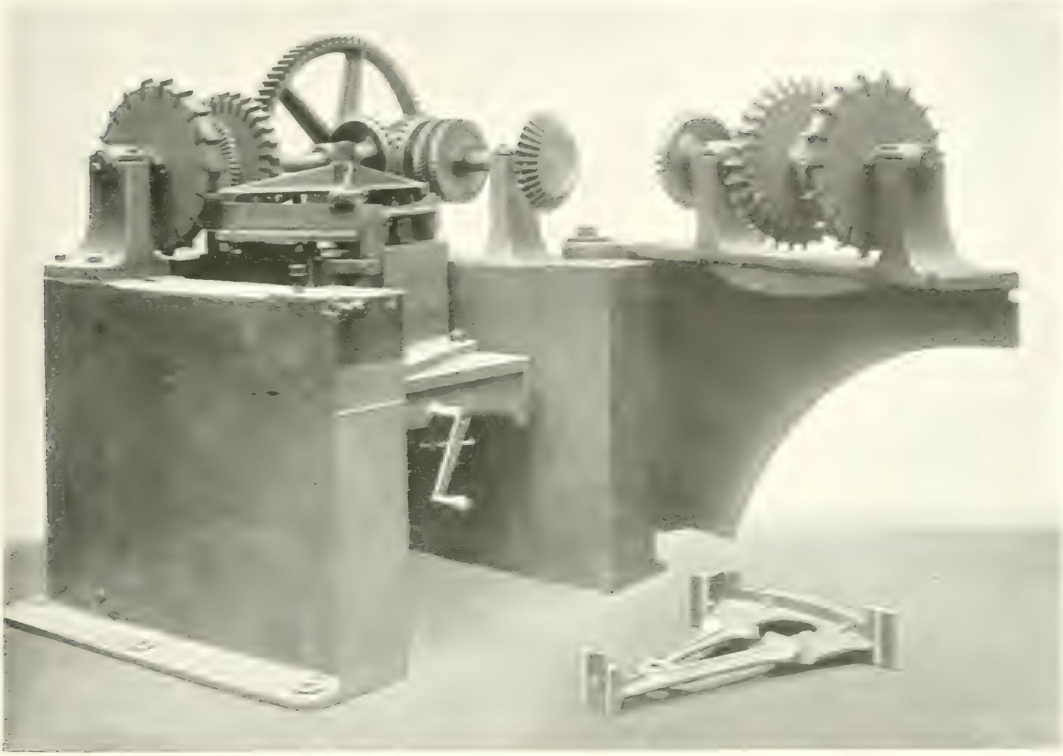


FIG. 5. SPECIAL MILLING MACHINE [illegible]
[illegible] LTD. [illegible]

fitting which can be attached to any planer converting it into a true milling machine, capable of doing everything that can be put on a plain miller.

The machine comprises two brackets which fit on the planer cross rail, one of which carries the spindle and its driving gear, the other the tail support. The operating gears are belted from a countershaft distinct from that of the planer. The spindle can be swivelled anywhere from vertical to horizontal, and a belt tightening device takes up or lets out slack to suit the different positions. The change from planing to milling, and *vice versâ*, can be made in a few minutes, so that the proper work of the planer is not stopped for any length of time by the rigging up of the milling head. There is also the advantage that work can be roughed out by one method, and finished by the other when desired, without having to reset it on different machines.

One of the later developments in milling is that of cutting worms and screw threads in machines of special construction. These have some advantages over single cutting tools, but can only be utilised economically when there is a constant run of this class of work.

CONCLUSION.

We [illegible] the milling machine through many phases, from the original Lincoln of light construction, employed only in [illegible] types which are now in[illegible] engineers' shops. There is not the slightest doubt that many other developments will grow out of these, as the practice of milling [illegible], and as firms specialise accordingly.

ELECTRIC POWER
AT THE
KOLAR GOLD FIELD.

BY

A. MERVYN SMITH.

This paper, describing in detail the largest electric installation in the world for mining purposes, is reproduced by the courtesy of the Institution of Mining and Metallurgy, with many original illustrations.

THE Kolar Gold Field is situated in native territory on the Mysore plateau, South India. At present there are eleven gold mining companies at work, all having their directorate in London; 10,500 h.p. is required to work the different engines in use on the fields, and to get the necessary energy, 190,000 tons of fuel—chiefly coal—are consumed annually, costing £230,000. There are 366 boilers (216 in use) on the fields, and the first cost of these, with the necessary housing, tall chimneys, etc., runs up the cost of engine-power, worked by steam, to more than £30 per h.p.

Mysore has no coal-fields of its own, so that the mining companies have to import from Singerini—600 miles by rail—or from Barrakar, in Bengal—400 miles by rail and 1,000 miles sea passage.

If Mysore has not got energy locked-up in the shape of coal, she has it in two of the finest waterfalls in India—the Gersoppa Falls, 900 ft. high and a quarter of a mile wide; the Cauvery Falls, 450 ft. high and half a mile wide. The first-named falls are 200 miles from the mines, and are situated in mountainous country difficult of approach with heavy machinery. The Cauvery Falls are only 92 miles from Kolar, and offer no great obstacles to the transit of heavy machinery, and it is from these falls that the power is generated and transmitted to work the electric motors in use at the Kolar Gold Mines.

The Rajah of Mysore—a tributary Chief under the British Government—owns the Kolar Gold Field, which is leased to various English companies, who pay him a royalty of 5 per cent on all the gold produced. Last year he received £95,200 by way of royalty; the total amount received since the mines were started being £715,700.

CAUVERY POWER SCHEME.

The gold-mining industry having proved so lucrative to the State, the native advisers of the Rajah were astute enough to see that, if the motive power going to waste in the province could be brought to do the work of the costly coal in use, at a less cost, the mining companies would be glad to get it, and the revenues of the Rajah would also benefit. Hence the Cauvery Power Scheme.

A series of gauging operations carried out for the purpose of testing the capabilities of the river under *minimum* conditions showed that water sufficient to generate 8,000 h.p. throughout the year was available, The services of Capt. de Lotbeniere, a Royal Engineer officer in the employ of the Government of India, were borrowed to elaborate a scheme, and he was deputed to visit England to confer with Professors Unwin and Forbes, the well-known scientists, to whom all details of the hydraulic and electrical plants were submitted for approval.

The supply and erection of the machinery was given to Messrs. Escher, Wyss and Co., Zurich, Switzerland, the electrical plant and its erection being entrusted to the General Electric Company of New York, United States, who also arranged to maintain and work the electric installation for twelve months after their completion.

The Cauvery river is one of the largest in South India, its length being about 470 miles. About 200 miles from its source it divides, forming an island three miles long and three-quarters of a mile wide. The river here has a northerly course, and about half-a-mile from the north end of the island the river makes a rapid descent of about 450 ft. in both its branches. Like most Indian rivers, the Cauvery brings down enormous volumes of water during the rains from June to October, as much as 239,000 cubic feet per second being gauged in flood-time. During the dry months, March, April and May, the water is only a fractional part of this. The river-works above the "intake" are shown in Plate I., and consist of two low level diverting dams: The upper dam diverts the water from the eastern branch into the western, where another dam diverts this joint supply into a draft channel leading to the sluice-gates at the head of the supply channels.

The head-sluice on intake is situated about two miles above the falls, and contains 8 vents, $4\frac{1}{2}$ ft. by 5 ft. (four to each channel), with rising shutters, and is flanked by a scouring sluice having four vents of similar dimensions.

The two channels, each of sufficient capacity to supply he turbines, are $3\frac{1}{3}$ miles in length. The grades of the channels are 1 in 5,000 for earth, and 3 in 5,000 for rock sections. Plates II. and III. show the channels in earth and rock sections respectively. The normal depth of the water is 5 ft., and from trials made in May, 1902, the

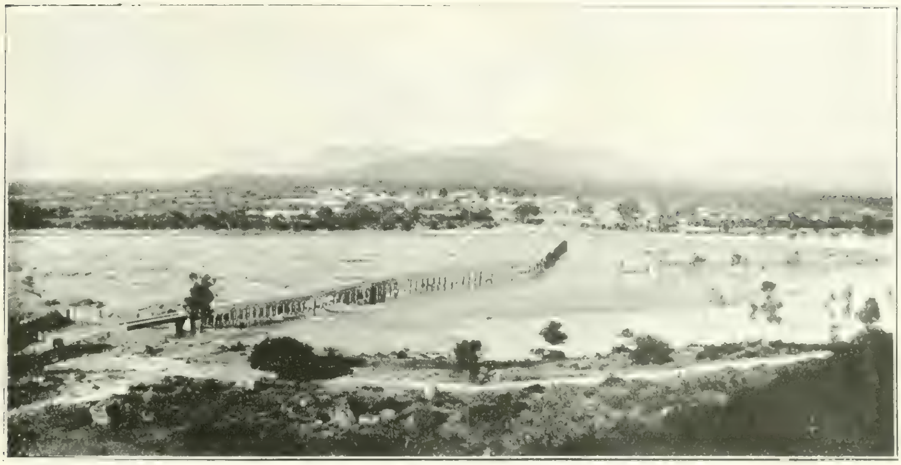


PLATE I. LOW LEVEL DIVERTING DAMS AND HEAD OF CHANNEL IN RIVER CAUVERY.

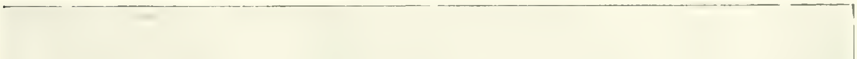


PLATE II. SUPPLY CHANNEL IN EARTH CUTTING.

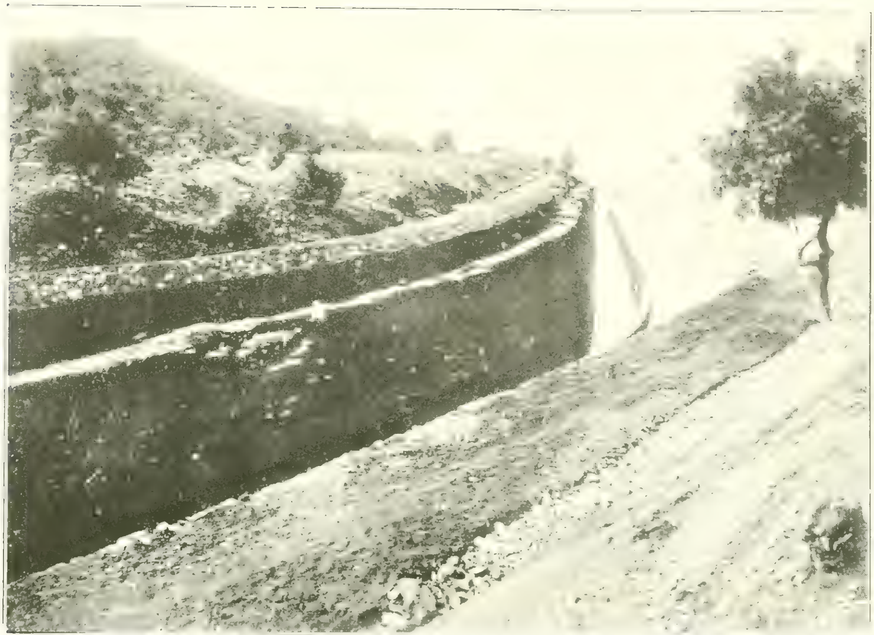


PLATE III. SUPPLY CHANNEL IN ROCK CUTTING.

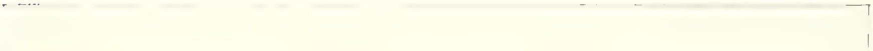


PLATE IV. GENERAL VIEW OF POWER HOUSE, PENSTOCKS AND TRANSFORMER STATION.

capacity is about 400 cubic feet per second. Ample provision is made in the banks of channels by way of escape-weirs to meet emergencies.

Plate IV. shows hydraulic house, transformer station at top of bluff, and three penstocks leading from Forebay to hydraulic house.

The Forebay at the tail end of the channels is situated at the brow of the bluff 900 ft. from, and about 400 ft. above, the hydraulic house. Iron grids intercept all leaves and other floating matter which may have fallen into the water during its three-mile course down the river. A separate chamber with double-geared gate contains the main valve at the end of each of the three penstocks.

The penstock pipes shown in Plate VI. are of riveted steel, ¼ in. to ½ in. thickness. They are 45 in. wide at top and 36 in. at the lower end. Expansion joints and anchorage is provided at three points on the steep hill-side.

The pipes, which are above ground for about four-fifths of their total length, being carried on substantial masonry piers 15 ft. apart. Each penstock pipe bifurcates at its lower end and serves two Pelton wheels of 1,000 h.p. each. Five of these wheels are in constant use, the sixth being held in reserve. Plate VI. shows penstocks in course of erection. The main valves on the penstock intakes are balanced, and will close automatically should a pipe burst at any point in the line below them. A separate 10-in. pipe carries the water from Forebay to the governor mechanism at the water-wheels in hydraulic house.

The makers, Messrs. Escher, Wyss and Co., of Zurich guarantee for the turbines, as follows :—

1,250 brake h.p. at the coupling, with 37 cubic feet of water per second, the effective head at wheel being 382½ ft. The turbine or wheel is of the Pelton type, 60 in. diameter, with an automatic governor of special construction.

Efficiency :—75 per cent. for full gate.
„ 70 per cent. for half-gate.

The nozzles are those of the type known as crocodile-jawed.

Railway communication exists to within 28 miles of site of hydraulic works. Some of the heavy pieces of the machinery weighed six to eight tons.

TRANSMISSION TO KOLAR.

The distance from the falls to the Kolar Gold Field is 92 miles. About 500 tons of copper wire were required for the transmission and distribution wire. The transmission to Kolar is effected by two parallel lines 60 ft. apart. There are three wires, No 0, B and S gauge, on each line, 40 in. apart, forming an equilateral triangle. The apex of the triangle is the top of the pole and the two lower wires are carried on a cross-arm. The poles are 130 ft. apart, and the lower wires are 20 ft. above ground. A telephone wire is carried on a separate cross-arm 6 ft. below the main wires. Plate VII. shows the transmission line in course of erection.

The maximum length of span at river crossings is 525 ft., and in all river crossings the wires are spread out horizontally 10 ft. apart, and are carried on special pole structures shown in Plate VIII. When crossing rivers, railways, and telegraph wires, a cable of silicon bronze is substituted for the ordinary copper wire. Transposition of the main line wires is made three times in the total length of 92 miles, in order to obviate induction and lessen impedience.

Each line of three wires is of sufficient capacity to transmit the full power at increased potential, to meet emergencies in the way of breakdown of lines or repairs ; but ordinarily both lines will be used for transmission, each carrying half the current. The poles supporting the transmission-lines are of Jarrah wood, specially imported from Australia. The lower portion of the pole consists of a steel pipe 13 ft. long, of which 7 ft. are embedded in the ground. Into this fits a Jarrah pole, 7 in. square and 29 ft. in length. The insulators used are imported from Italy, and consist of a fine petticoat of porcelain, supported on steel pins set in Portland cement.

ELECTRIC GENERATING STATION.

Plate IX. shows the electric generating station at the falls. The generators are three-phase alternators with a revolving field and stationary armature. The rated output is 720 kilowatts ; the frequency 25 cycles, speed being 300, and voltage 2,200. The excitation for the fields of the alternators is supplied from two independent 75 kilowatts exciters, separately driven by two small turbines of type identical with the main wheels, the speed being 465. One complete unit and one exciter-set forms the reserve as regards generating plant. The cables conducting the current from the power house are lead-coated, and are carried on stone shelves within an enclosed masonry passage or duct up the face of the bluff to the transformer house, where the voltage is raised from 2,200 to 30,000 (the line potential) by means of static transformers. These are twelve in number, each of 400 kilowatts capacity, in four blocks of three, one of which forms the reserve. Air blast for cooling the transformers is supplied by electrically-driven direct coupled blowers, through an air-chamber immediately under the transformers. There are similarly driven air-compressors, fanning air 60 lb. pressure, for blowing out dust that may settle on the apparatus.

TRANSFORMER HOUSE, KOLAR.

On reaching the Kolar Goldfield the double transmission line enters the transformer house situated on the Champion Reefs Mine. This is a two-storey structure, 88 ft. by 34 ft., and 30 ft. high above the main operating floor, and with a basement 9 ft. high. The six high-tension wires are each connected to the line of panels, equipped with two sets of switches, and from these switches the lines are connected to a set of bus-bars strung the entire length of the building. From these the connections are taken to four groups, each of three high-tension transformer panels, all eighteen panels being located in the gallery 11 ft. above the main operating floor. All panels are equipped with snap switches and operating levers from oil switches, which latter are located in a fire-proof chamber under the gallery. This chamber is separated from the main operating floor by a brick wall, through which the high-tension wires are carried on soap-stone and porcelain insulators. From the oil switch chambers the leads are brought in group or three to the high-tension sets of step-down transformers. The high-tension windings are designed for 20,000 volts potential, and the low-tension windings for 2,300 volts.

Each of the twelve transformers has a capacity of 350 kilowatts, at 90 per cent. power factor. The total kilowatt capacity of the switch station is, therefore, 4,200 kilowatts ; but as only nine out of the twelve transformers are expected to be in operation at any one time, the working capacity is 3,100 kilowatts, or 4,222 h.p., leaving 1,050 kilowatts in reserve. The transformers are of the air-blast type developed by the General Electric Company of New York, of which there are in actual service in the United States and other countries on the 1st May, 1900, over 200,000 kilowatts capacity.

The air circulation through the transformers is provided for by a supply of two 80-in. blowers, operated by 7½ h.p. three-phase induction motors. One of the above blowers is sufficient to provide air circulation for the entire installation of transformers, the second standing in reserve. The secondary leads for the transformers pass down through the air duct, which also forms the foundation for the transformers, and are carried through the foundation-wall into the basement and along the ceiling of this to the low-tension oil switches, which are operated from transformer control-panels placed on the main operating floor. The switches, which are located in the basement, are handled by levers placed on the switchboard panels. In addition to these levers, each of the transformer panels contains ammeters to give indications of the work performed by each group of transformers.

The leads, after passing through the oil switches and instruments, are connected to a set of low-tension busbars, from which connections are taken to the various feeder-panels. Each mining property has a separate feeder-panel to its outgoing leads, each panel is equipped with an oil-switch recording and indicating watt meters, and an additional ammeter for those circuits which carry synchronous motors. By this arrangement a complete record can be carried of the work performed in kilowatts during any given period or for instantaneous observations, and the power-factor of the synchronous motor circuits can be obtained at any time.

From the feeder panels the circuits are carried through the basement into a low-tension distribution wire tower, forming a part of the main building on the east side, where provision has been made for doubling the present capacity of the station. Eight feeders extend north, eight south, and eight west. Each of the feeder circuits consists of three wires, making a total provision, therefore, for 72 wires leaving the station. The size of these wires varies from ·460 in. to ·325 in., depending upon the distance transmitted and the amount of work to be performed by each feeder. The station is equipped with one 5-h.p. air compressor and tank—all the apparatus to be cleaned by compressed air—100 lb. pressure pipe connections being laid through the entire building to convenient points for connections to cleaning hose. To facilitate the handling of heavy apparatus a hand-power crane, capable of lifting 10 tons, is placed close to the rafters. The heaviest piece of apparatus is the transformer, which weighs 12,770 lb. In the basement is located all the low-tension wiring, oil-switches, blowers, and air-receivers. The station is lighted by incandescent lamps, operated through transformers from the main transmission station.

SWITCHBOARDS.

These are all built on heavy polished blue Vermont marble supported on angle irons with nickel-plated bolts. The instruments and other work are finished in dark oxidised copper, the whole presenting a handsome appearance combined with the greatest attainable utility for the complete and easy control of each section of the extensive distribution system.

DISTRIBUTION CIRCUITS.

The poles supporting the wires are of the same general construction as the main line between the Cauvery Falls and the Goldfield, except that they carry four cross-arms each with six wires. The lower half consists of a 7-ft. steel pipe, 13 ft. long, weighing 300 lb., and the upper half consists of a 7-in. wooden pole, sawed square, 17 ft. long, with 21 in. of the lower end rounded and pressed into the iron socket. The cross-arms are made of teak specially selected to stand the heavy wire strain. The insulators are of the three-petticoat type.

For the present installation seven feeders go north from the station to the properties of Nundydroog, Oriental, Coromandel, Balaghat, Gold Fields, Nine Reefs and Road Block. On the east the feeders extend to the Ooregaum property, and south, one circuit for Champion Reef, and three circuits for the Mysore properties. The main line for the distribution runs very nearly north and south, crossing the Madras Railway, on the Balaghat property, with branch lines also crossing the railway on the Mysore, Champion Reef, Ooregaum and Nundydroog properties. The total weight of copper for the distribution system is 182,300 lb., exclusive of the wire, connecting sleeves and other details. Four hundred poles are required to cover the entire field.

All motors of 200 h.p. and smaller sizes are of the induction type, without any brushes, collectors or commutators to take care of. Sizes of 200 h.p., 150 h.p., and 100 h p. are wound for 2,080 volts, connected directly to the distribution mains, and all smaller motors are wound for 220 volts, with smaller step-down transformers used between the distribution mains and the motors. In order to secure the needed variable speeds a rheostat is placed in the armature circuit, the control of which is effected by a simple movement of a lever-like electric street-car controller.

An induction motor is composed of two principal parts: 1st. The stator, or stationary part, which has its winding connected to supply circuits. 2nd. The rotor, or revolving part, with its shaft and pulley supported on two or more bearings, and this winding is either closed upon itself (short circuited) or closed through external or internal resistances –this winding receiving its current inductively, having no other connection with the stationary winding. The electro-motive force induced is of low potential, in many cases only a few volts, but the current is high in amperès. The absence of brushes or commutators, which are so prominent in the usual direct-current machines, makes the motor look as if it were

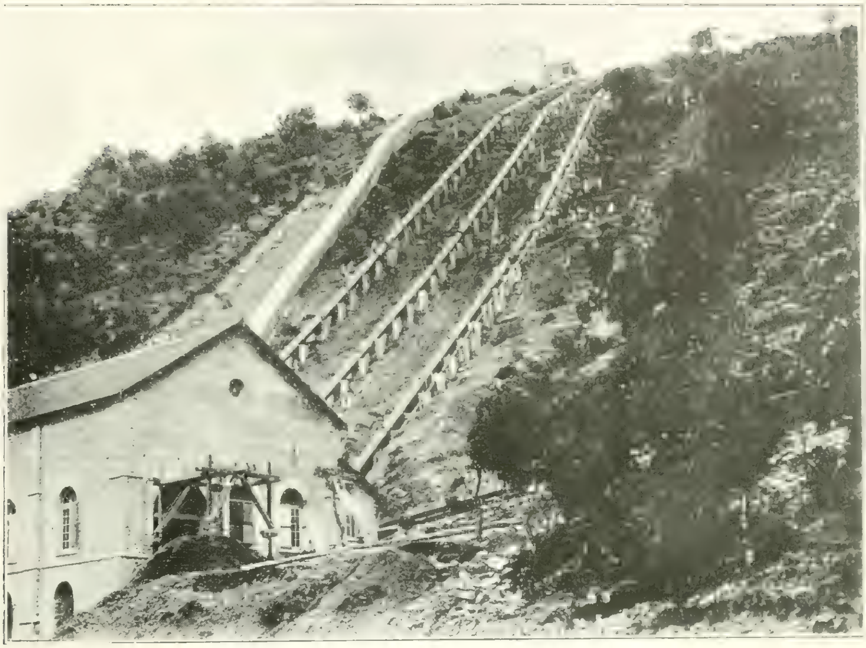


PLATE V. PENSTOCKS LEADING FROM FOREBAY TO HYDRAULIC HOUSE.

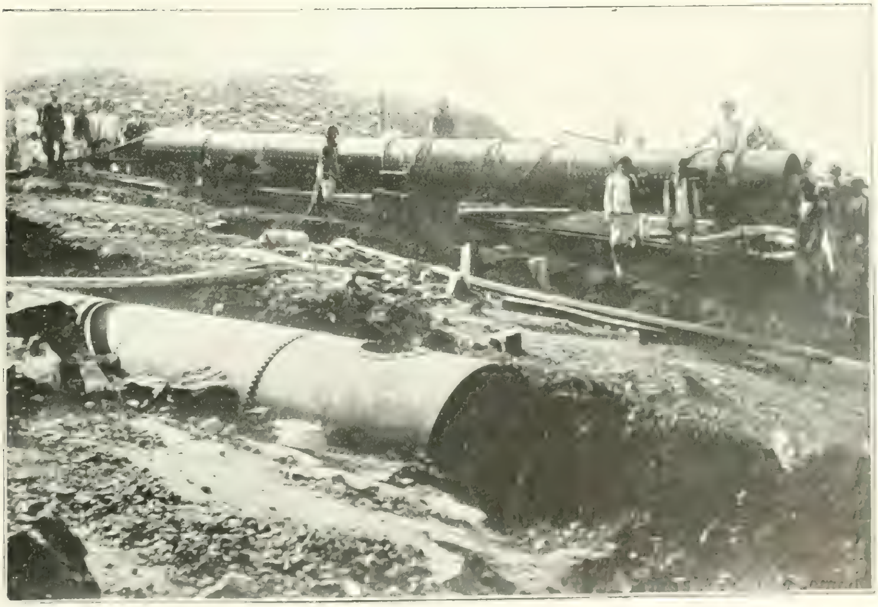


PLATE VI. PENSTOCKS IN COURSE OF ERECTION.

only a mass of iron with a few copper bars that revolved, developing hundreds of horse-power, which with a steam-engine and boilers would require a building many times the size, together with the large and complicated machinery, and a large staff of skilled mechanics to keep it running. In the case of the induction electric motors, no man of greater skill than an ordinary millwright is needed for their operation and handling; for as long as there is oil in the bearings and electric current supplied, no man can prevent its turning the mill or compressor—and the oil in the bearings need not be replaced under ordinary circumstances oftener than once in three months; and practically the only attention needed is to keep the machinery clean, which duty is different in the various localities.

SYNCHRONOUS MOTORS.

The synchronous motors, which are used in sizes of 300 and 400 h.p. are more complicated, and need more careful attention than the induction motors above mentioned. A synchronous motor is practically an alternating current generator reversed, *i.e.*, it receives an electric current and develops power at the pulley. Its construction is identical with a generator, and it can be used as either a generator or motor. The particular type used on the Kolar Gold field is the one called Revolving Field type, because of its construction with the continuous current excited field revolving and the stationary alternating current armature which is connected to the distribution circuits. The exciter for each machine is mounted on the motor shaft in front of the machine. The windings of these motors are all for 2,080 volts and operated with the slow speed of 250 revolutions per minute. The pulleys are made for rope-drive, and the duty of this class of motors is in the present installation confined to compressors only.

COMPRESSORS.

The pressure used is mostly 45 lb., but all the 11 new compressors which are being installed in connection with the electric-power plant are designed for 60 lb. pressure. The present installation consists of:—

Five 150 h.p. duplex air-compressors, each cylinder 16¼ in. in diameter, 18-in. stroke, speed 110 revolutions, capacity to compress 910 cubic feet of air per minute to 60 lb. per square inch pressure. The driving pulley is 10 ft. in diameter, and grooved to receive 9 ropes 1¼ in. diameter. The air receivers are 48 in. in diameter, and 12 ft. long.

Four 200 h.p. duplex air-compressors, each cylinder 18¼ in. in diameter, 24-in. stroke, speed 94 revolutions, capacity to compress 1,314 cubic feet of free air per minute to a pressure of 60 lb. per square inch. Driving pulley is 13 ft. diameter, and grooved to receive 12 ropes 1¼ in. in diameter. Air-receiver 54 in. by 12 ft. long.

One 300 h.p. duplex air-compressor, each cylinder 22½ in. in diameter, 24-in. stroke, speed 94 revolutions, capacity to compress 1,920 cubic feet of free air per minute to a pressure of 60 lb. per square inch. Driving pulley 13 ft. diameter., grooved to receive 12 ropes 1$\frac{1}{2}$ in. in diameter. Air-receiver 54 in. by 12 ft. long.

One 400 h.p. duplex air-compressor, each cylinder 25¼ in. diameter, 30-in. stroke, speed 80 revolutions per minute, at which speed the capacity is 2,600 cubic feet of free air per minute at a pressure of 60 lb. per square inch. Driving pulley is 16 ft. in diameter, and grooved for 16 ropes 1½ in. diameter.

All compressors have piston inlet air-cylinders, with water jacket all round the walls and through all heads, and are provided with automatic sight feed lubricators for air-cylinder jackets, automatic air-pressure regulators, piping, and all other necessary details which form part of a complete installation. All compressors hitherto used on the field have been steam-driven, carrying a small fly-wheel to equalise the angular velocity. In the case of the new compressors these are driven by a large pulley through the elastic medium of ropes, which has proved so eminently successful in many large motor-driven installations. The compressors and air-tanks are manufactured by the Ingersoll-Sergeant Drill Company of New York, this company being sub-contractors for this section of the work to the General Electric Company of New York.

DETAILS OF MOTOR APPLIANCES.

The present equipment of the goldfield consists of 32 electric motors, with a total capacity of 4,205 h.p., of which 11, with a capacity of 1,530 h.p., are to operate crushing mills; 12, with an aggregate capacity of 2,550 h.p., to operate the air-compressors.

Five, with an aggregate capacity of 60 h.p., to operate hoists; two, with an aggregate of 50 h.p., to operate stone breakers; one, of 5 h.p., to operate the triplex pump; one, of 10 h.p., to operate the machine shop.

The extent of the goldfield over which the motors, etc., are distributed is about six miles in length and one in width. It may be noticed that the total loss in transmission between the generators at one end, and the motors at the other end of the system is approximately 20 per cent.; an output of nearly 5,000 h.p. at the Falls power station being requisite for the delivery of 4,000 h.p. at the Kolar Gold field.

COST OF SCHEME.

	£	s.	d.
1. Hydraulic plant	26,500	0	0
2. Electric plant, generators, and transmissions	112,000	0	0
3. Distribution plant	53,000	0	0
4. Channels, buildings, &c.	48,000	0	0
Total	£340,100	0	0

The present agreement with the mining companies concerned is for the supply of 4,000 h.p. (full time) for a period of ten years. The rate per h.p. per annum varies during the first five years from £18 to £29, the average being £20 4s. For the second five years a uniform rate of £10 per h.p. is to be paid by the mines.

On this basis, after making full provision for working expenses and depreciation, it has been calculated that the Mysore State will recoup practically the whole capital outlay by the end of the sixth year, and obtain revenue equal to 10 per cent. afterwards. It has also been established that the mining companies should save in working

Electric Power at the Kolar Gold Field.

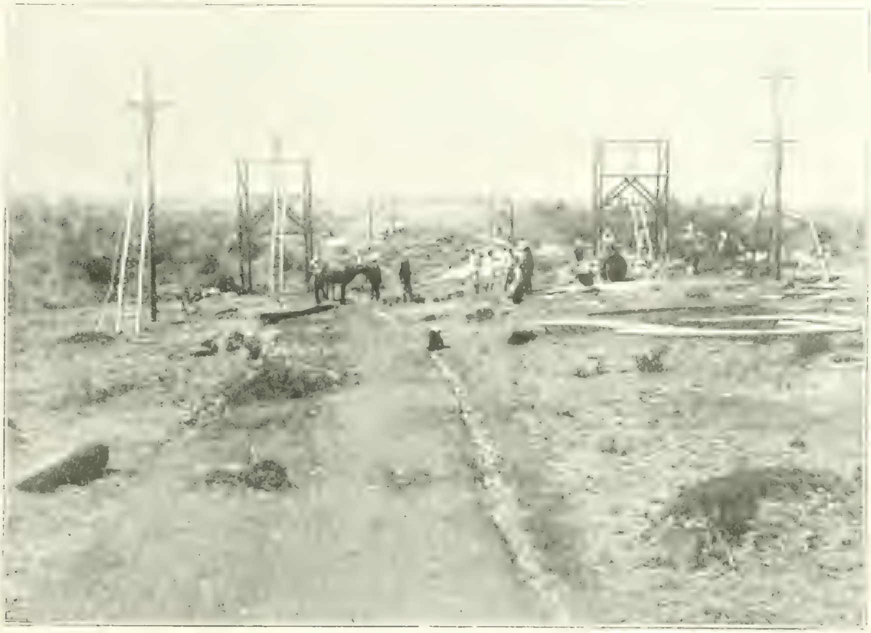


PLATE VII. TRANSMISSION LINE IN COURSE OF ERECTION.

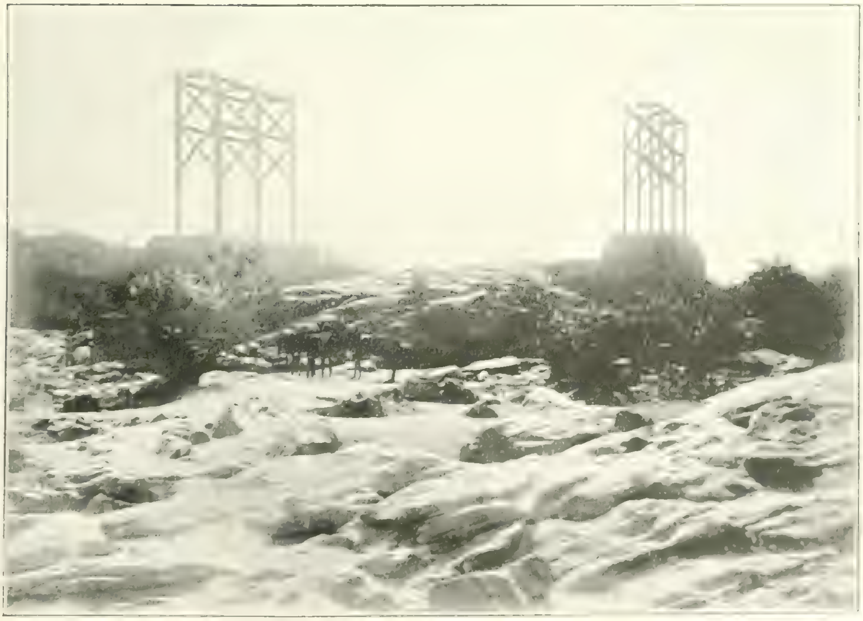


PLATE VIII. TRANSMISSION LINE AT RIVER-CROSSING.

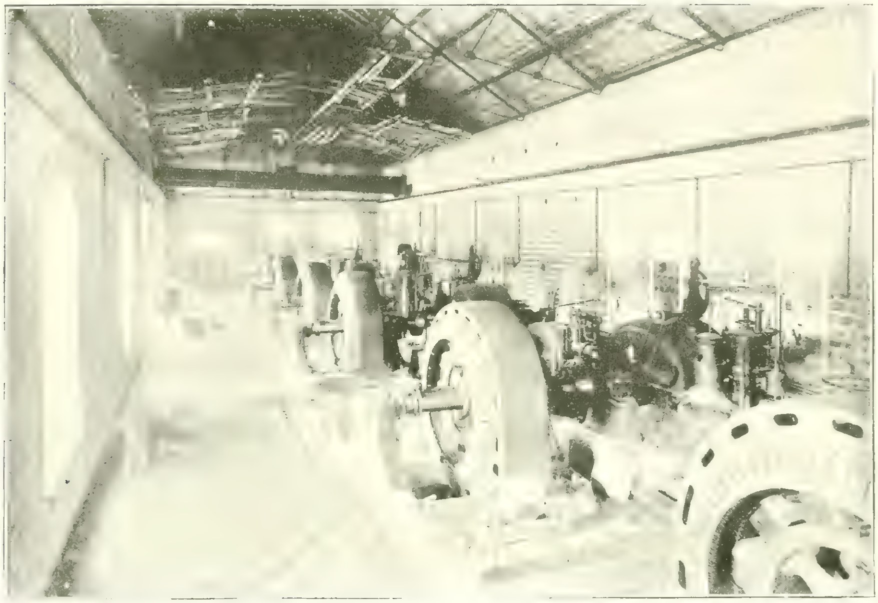


PLATE IX. ELECTRIC GENERATING STATION AT FALLS (SWITCH-BOARD).

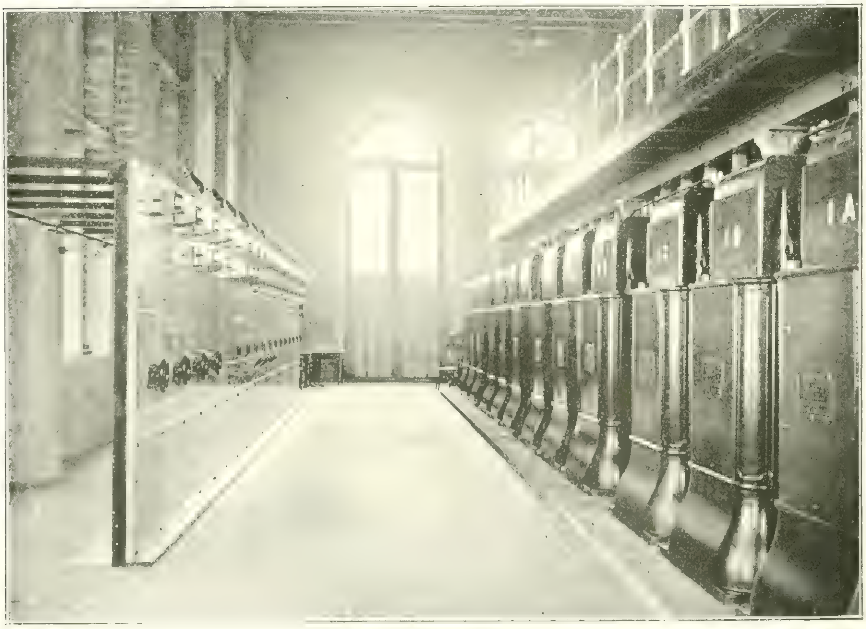


PLATE X. GENERAL VIEW OPERATING FLOOR, TRANSFORMER HOUSE, KOLAR.

expenses well over half-a-million sterling during the time the contract lasts.

On July 29th last the motors were at work on the field: the first shipment of line material arrived in India in January, 1901, so that within eighteen months the whole plant was erected and at work. It has now been at work for three months (October 30th), and, with the exception of a stoppage of two hours to repair damages owing to the transmission-line being struck by lightning during a severe thunderstorm, it has worked without a hitch and has given general satisfaction at all the mines using electric power. The uniformity of the power supplied enables 20 per cent. more work to be done. With steam there was always a fluctuation in the power delivered, owing chiefly to faulty firing during the night. Less supervision, less machinery, and better results at cheaper cost are some of the benefits conferred by the utilisation of the Cauvery Falls power electrically transmitted to the Kolar Goldfield.

It is intended shortly to duplicate the plant employed so that 8,000 h.p. will be transmitted to the field. Should more power than this be required, an extensive reservoir would have to be built above the Falls to hold the flood-waters of the Cauvery, as the dry weather supply in the river would be inadequate.

So accurate is the mechanism of the governor connected with the Pelton wheels at the power station at the Cauvery Falls, that a stoppage of any of the electric motors on the Kolar Gold field immediately acts on it, and causes a contraction of the nozzles discharging on the vanes of the hydraulic wheels and lessens the power generated in a corresponding ratio. Several trifling accidents have happened since the installation at the fields. An adventurous cat sprang on the bus-bars of the step-down transformers at the Champion Reefs Distribution House, and was promptly electrocuted.

The loss of power in line transmission along the 92 miles of line between the falls and Kolar is calculated at 13 per cent. when all six wires carry the current. If only three wires are used, the loss is doubled, and consequently the wheels have got to do increased work. On one occasion one of the two lines was being repaired, and full power had to be sent on a single line of three wires at increased potential. To enable the wheels to do this increased work, the nozzles had to be opened to their fullest extent, and this caused a greater discharge of water through the penstocks, and exhausted the supply over the penstock [illegible] Forebay and caused a stoppage of the machinery. By slightly raising the retaining wall of weir at the Forebay, and thus increasing the head of water over the self-acting sluice-gates, the recurrence of such an accident has been obviated.

When the power has got to be uniform, as in the case of stamping-mills and compressors, the advantages of the electric motors are most pronounced, but where the load is not uniform, as in the case of hauling in deep shafts, the advantages over steam-power are not so great. Thus if 100 h.p. steam engines were required to do the hauling at a depth of 2,500 ft., less steam would be employed and less power developed when hauling from the 1,000 level.

The arrangement made with the Mysore Government by the companies using electric power is for a fixed amount of power per day, whether the power is used or not. So far, none of the companies have used the full contract amounts; still, they have to pay for power not used. When machinery actuated by electric motors is being cleaned or repaired, or not in use, full power has got to be paid for. With steam-power there would be a saving of fuel in such cases; whereas with electric power under the present arrangements with the Mysore Government, full contract power has to be paid for. During the last three months the companies using electric power have paid for 20 per cent. more power than they are using. If the meter rate were introduced, and the companies only paid for what the meters showed as consumed, there would be considerable saving. On behalf of the Mysore Government it is contended that as it is impossible to tell how long the mines will last, it is the business of the State to get back their outlay as soon as possible, and this they hope to do within five years; hence the present system of charging for power whether it is used or not.

The advantages of electric motors and electric distribution of power, judging from the results obtained at Kolar, are so great that it is thought that for mining purposes, where power is required in dozens of different localities some miles apart, power generated at a central station by steam and distributed electrically would be more economical than a series of steam-generating stations scattered all over the field.

I am indebted to Lieut. Hunter, the Engineer of the Mysore Government, and Alex. Extrom, the Chief Electrical Engineer of the General Electric Company, for much of the information contained in this paper.

NOTES & NEWS

Submarines on Trial.

IN 1900 the United States Government ordered seven diving torpedo-boats from the Holland Torpedo Boat Company, and in the same year the British Government ordered five vessels from the Company.

All the British boats have run their trials. They are known as Nos. 1, 2, 3, 4, 5, and although no official statements have been made concerning their trials, these are believed to have been perfectly satisfactory. Two are now at Portsmouth, and the remainder will shortly leave the yard of Messrs. Vickers, Sons, and Maxim, at Barrow, for the southern port. Of the new "Vickers-Admiralty" boats, known as A1, A2, A3, and A4, one has been launched. The other three are still on the stocks.

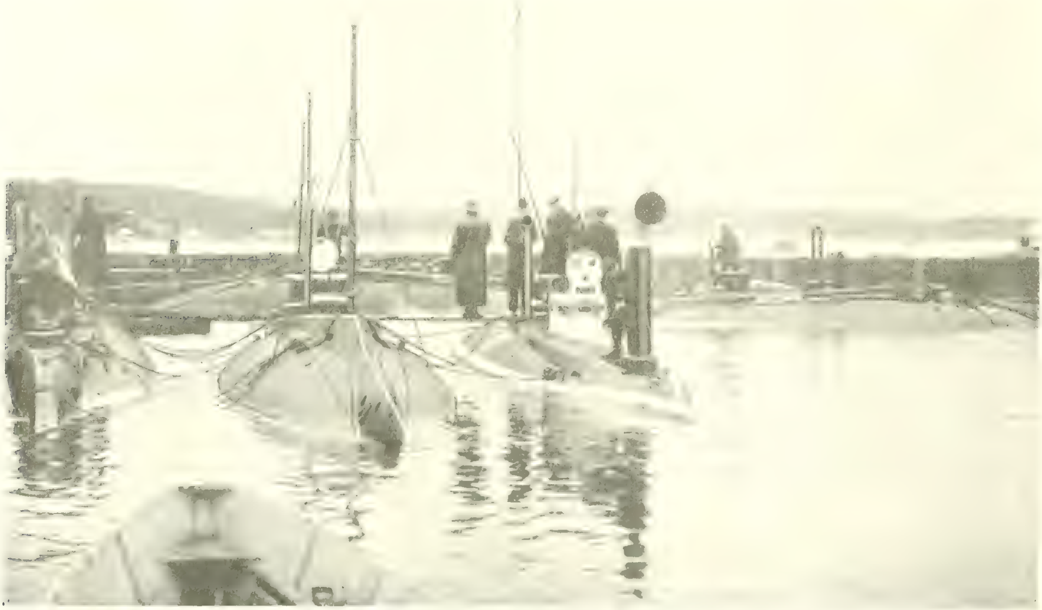
Before the United States Government ordered these diving torpedo-boats they had only one submarine on their navy list. This was the *Holland*, purchased by the United States, April 11th, 1900.

From a statement prepared by Rear-Admiral F. T. Bowles, Chief of the Bureau of Construction and Repair, United States Navy Department, it appears that the actual construction of modern submarine torpedo-boats for the United States Navy was initiated by the Act of March 3rd, 1893, which provided for building a submarine torpedo-boat and conducting experiments therewith, authorising the expenditure of 200,000 dollars for the purpose. Eventually in 1900 the following vessels were ordered :—

1. *Adder.*
2. *Grampus.*
3. *Moccasin.*
4. *Pike.*
5. *Porpoise.*
6. *Shark.*
7. *Plunger.*

The *Adder* and the *Moccasin* have at last completed their trials and have been accepted by the United States Navy Department.

The *Adder*, *Moccasin*, *Porpoise*, *Shark*, and *Plunger*, were built in the yards of Lewis Nixon, at Elizabeth Port, New Jersey.



THE SUBMARINE TORPEDO-BOATS "ADDER," "MOCCASIN," "PORPOISE," "PLUNGER" AND "SHARK."

THE UNITED STATES SUBMARINE TORPEDO-BOAT "ADDER," AT FULL SPEED, UNDER GASOLINE ENGINE.

The *Grampus* and the *Pike* are being built at the Union Iron Works, San Francisco.

The following is a summary of the chief features of interest in the recent trials of the *Adder* and the *Moccasin*, which are practically identical with British Submarines Nos. 1 to 5.

The other five American submarines have still to undergo their contract trials before being accepted by the Government.

The *Adder* and her six sister vessels are 63 ft. 4 in. long, 11 ft. 9 in. beam, and 11¾ ft. diameter. The displacement when submerged is 120 tons, the indicated horse-power on the surface under the gasoline engine is 160; and, submerged, under electric motor, 70 h.p. for 1,940 ampère hours.

The contract speed on the surface is 8 knots, and submerged 7 knots, and the result of the trials of the *Adder* and *Moccasin* was that both exceeded their contract speeds.

The *Adder* made an average speed on the surface of 8·5 knots an hour when running in the light condition, *i.e.*, with all her submersion tanks empty. In the partially awash condition she made an average speed of 8 knots an hour, and when totally submerged her speed was 7·5 knots. She therefore exceeded her contract speeds by half a knot on the surface, by 1 knot when awash, and by half a knot when completely submerged.

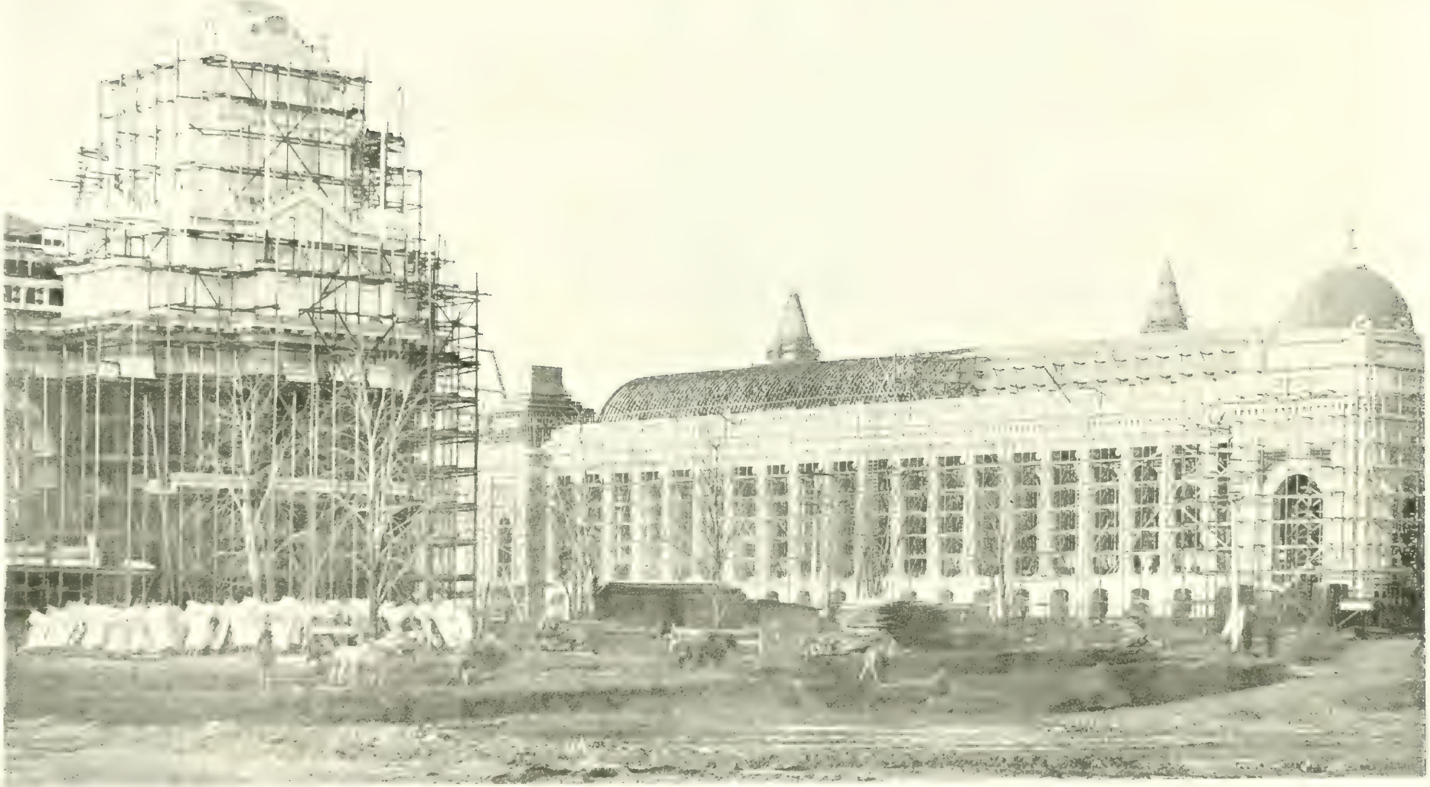
The *Moccasin* did not make quite as fast times as the *Adder*, but she was, on the whole, considered the steadier vessel.

The United States Navy Department required that on a two-mile run the boats should come to the surface but three times, and that a target 15 ft. deep and 150 ft. long must be struck by a torpedo.

During the trials the *Adder* made a submerged run of one mile, and fired a torpedo under water. A slight mishap is reported, for she ran aground when below the surface. The *Adder* immediately blew out one of her ballast tanks, and at once rose to the surface. It is said that the atmosphere on board became exceedingly [illegible], though the crew [illegible] serious discomfort.

The *M*[illegible] fired a torpedo [illegible] three times, none of more than 35 seconds' duration, to get her aim. The torpedo was deflected and did not hit, though it passed quite close to the target.

Further trials are to be made to test the capacities of the boats in deep water and in rough weather.



WORLD'S FAIR, ST. LOUIS, 1904.

View of Varied Industries Building from the South; Tower of the Electricity Building on the left; Ornaments for Electricity Building standing on the ground in the left of the picture; Excavation for the Grand Lagoon in the foreground.

Notes and News.

The Naval Board of Inspection of the United States Navy have issued an interesting and full report of the trials of the *Adder* and *Moccasin*. From this it would appear that the American boats are not so handy as the British vessels, taking longer to fill their tanks and disappear than do the latter. This is, of course, a matter of great importance for a diving torpedo-boat must be able to change from the light to the awash condition, and from the awash to the totally submerged condition, in as few minutes as possible.

The Andrew Carnegie Research Scholarship.

Candidates for the Research Scholarship or Scholarships, founded by Mr. Andrew Carnegie and awarded annually, irrespective of sex or nationality on the recommendation of the Council of the Iron and Steel Institute, should apply, on a special form, before the end of February, to the Secretary of the Institute (Mr. Bennett H. Brough).

The object of this scheme of Scholarships is not to facilitate ordinary collegiate studies, but to enable students who have passed through a college curriculum or have been trained in industrial establishments, to conduct researches in the metallurgy of iron and steel and allied subjects, with the view of aiding its advance or its application to industry. There is no restriction as to the place of research which may be selected, whether university, technical school, or works, provided it be properly equipped for the prosecution of metallurgical investigations. Candidates must be under thirty-five years of age.

The appointment to a Scholarship is for one year, but the Council may at their discretion grant a renewal for a further period instead of proceeding to a new election. The scheme provides that the results of the research shall be communicated to the Iron and Steel Institute in the form of a paper to be submitted to the annual general meeting of members, and if the Council consider the paper to be of sufficient merit, the Andrew Carnegie Gold Medal is awarded to its author. Should the paper in any year not be of sufficient merit, the medal is not awarded.

Last year the Andrew Carnegie Gold Medal was awarded to Dr. J. A. Mathews, New York; and scholarships, each of the value of £100, were awarded to: O. Boudouard, Paris; W. Campbell, New York; A. Campion, Cooper's Hill; P. Longmuir, Manchester; E. Schott, Berlin; F. H. Wigham, Wakefield.

A Large Blowing Engine.

The London office of Fraser and Chalmers, Limited (Works, at Erith, Kent), have recently received an order from the Moss Bay Hematite Iron and Steel Company, Workington, Cumberland, for one of their double vertical King Riedler Blowing Engines. The normal i.h.p. of this machine is about 2,000, the maximum being 3,000. The capacity of the machine normally is 20,000 cubic feet of free air per minute to 30 lb. blast pressure, the maximum being 30,000 cubic feet. One side of the blowing engine can be disconnected and run alone, giving a capacity of 15,000 cubic feet of free air per minute. The blowing engine will supply air to Bessemer converters, and its speed will automatically regulate itself according to the amount of blast required. The steam cylinders on each side are of Corliss type and compound, while the air cylinders are fitted with the Riedler patent valve. The initial steam pressure with which these engines will work will be 150 lb. with a vacuum of 10 lb. The normal speed is 50 revolutions and the maximum 75. The stroke is 54 in.

Institution of Gas Engineers.

The Incorporated Gas Institute, and the Incorporated Institution of Gas Engineers have been dissolved, for the purpose of forming a united society under the name of "The Institution of Gas Engineers." The necessary arrangements having been successfully completed, the Institution has been duly registered, the offices being at 39, Victoria Street, Westminster. The secretary is Mr. Walter T. Dunn.

Edison's Storage Battery.

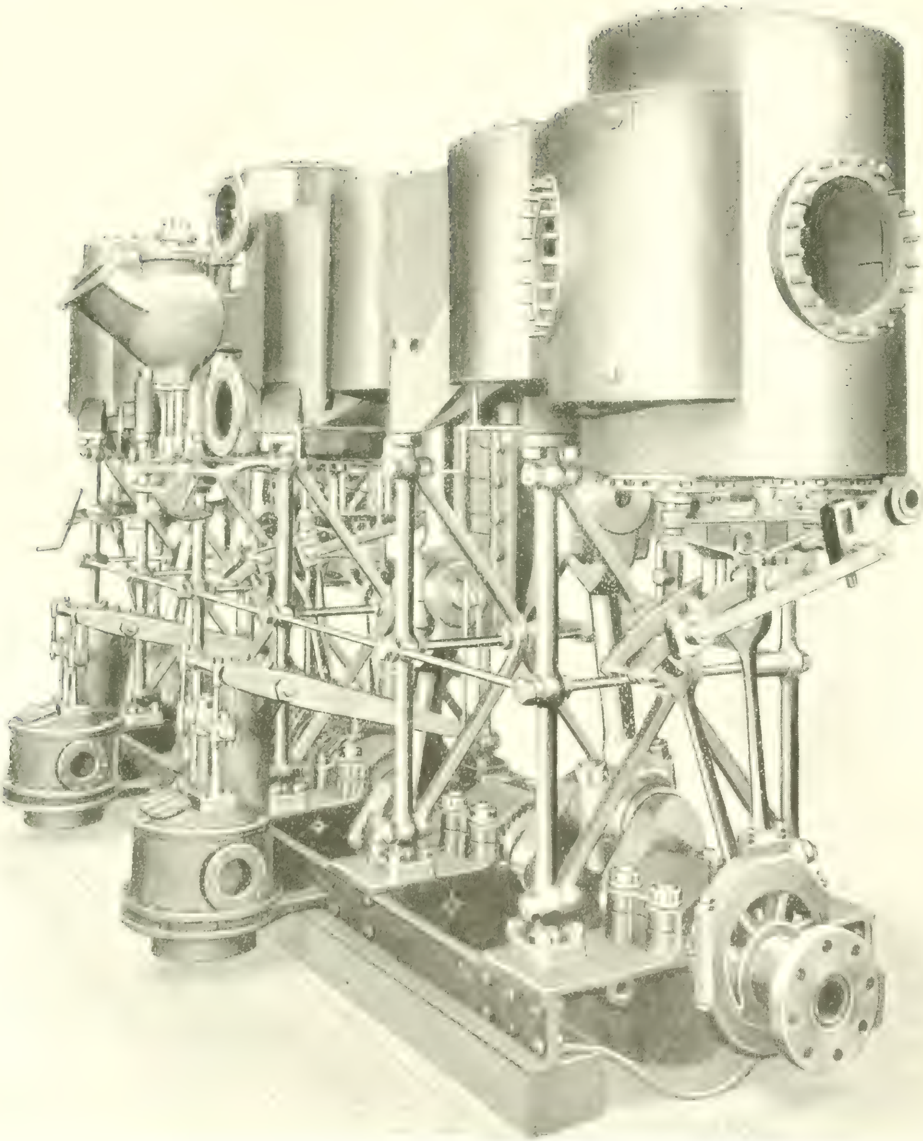
Mr. Edison, whose latest form of storage battery aroused considerable interest a few months back on account of the high claims made for it, is reported to be building five electric automobiles to run 5,000 miles each. They will all be equipped with his new battery, which it is the sanguine hope of Mr. Edison will enable a run of 100 miles to be made on one charge. A light run-about car is said to have recently covered 62 miles with a battery of 21 cells, weighing 332 lb., and at the end of the trial the car still ran at 83 per cent. of its normal speed.

Improvements at Chatham Dockyard.

An important scheme is being considered by the Admiralty for the construction of a new basin at Chatham to accommodate the warships attached to that port. The site provisionally selected is on the north side of the fitting-out basin, and communication with the river Medway could be easily effected. Each of the three basins already in existence has a water area of about twenty-six acres, but the accommodation thus provided is altogether inadequate, and it has been found necessary to moor certain of the ships in some of the reaches of the Medway. The new basin will have a water area of about sixty acres.

The authorities are greatly disappointed about the new dry dock at Chatham, which it was expected would be completed very shortly. A "blow" in the wall of the adjoining basin caused the new dock to be flooded; and in order to stop this, it has been found necessary to construct an additional dam right out round the defective portion of the wall; to cut what is technically known as a "grip" right through the wall itself, and to close pile it. The object of the piling is to prevent the water getting through beneath the foundations of the wall. The work has been of a most difficult nature, and has been mostly performed by divers. The water in the dock has been gradually lowered by means of powerful pumps, but no attempt will be made to clear it altogether until the "blow" has been effectually stopped.

[illegible]



ENGINES OF THE "TRENTON."

length is very pressing. At the present time there is only one dock at Chatham Dockyard capable of receiving vessels 440 ft. in length, the other three docks being only able to take in vessels 405 ft. in length.

Whilst accommodation is being provided at Chatham for the reception of battleships and first-class cruisers of the largest type, the Admiralty have also furnished the means for producing these giant ships. A new building slip has been constructed, with machinery shops and storehouses, and will be ready for use directly the huge derricks now being erected are in position. Labour-saving machinery of the most improved pattern has been installed in the shops, and the motive-power will be electricity. The total cost of the new building slip and its adjuncts and accessories has been about £150,000.

The Largest Destroyers in the United States Navy.

The torpedo-boat destroyers *Truxton*, *Whipple*, and *Worden*, built by the Maryland Steel Company, Sparrow's Point, Md., U.S.A., for the United States Government are the largest destroyers in the United States Navy, and as will be seen from the log of the official trial of the *Worden*, they are among the speediest.

The following is the log of the *Worden* on the official trial at the Barren Island course :—

Run.	Revolutions.		Steam.	Time.	
	Port.	Starboard.		Min.	Sec.
1	622	642	114	2	30·4
2	650	665	116	2	35·0
3	637	656	146	2	18·0
4	657	672	146	2	22·8
5	630	651	173·5	2	10·8
6	664	674	175	2	14·5
7	651	660	202	2	03·7
8	674	684	207	2	09·7
9	668	671	238·5	1	58·0
10	680	690	232	2	03·2

The corrected official time for the fourth run gives a speed of 30·05 knots per hour. On the hour's run on September 12th, 1902, the revolutions were 314·3 port and 314·5 starboard, giving a speed of 28·15 knots per hour.

Their dimensions are as follow :—

	ft.	[illegible]
Length over all	[illegible]	6
Length on trial load water line	[illegible]	0
Breadth on deck	[illegible]	6
Breadth on trial load line	22	6
Depth amidships ...	14	8

The engines are of the four-cylinder, triple-expansion type, placed in separate water-tight compartments, the forward engine being on the starboard side and the after one on the port side. The sequence of cylinders is as follows ; beginning forward, first low-pressure, intermediate, high, and second low-pressure. The cranks are at 90 degrees, the high and first low-pressure cranks being opposite, as are also the intermediate and second low pressure. Steam is supplied by four water-tube boilers of the Thornycroft type, constructed for a working pressure of 240 lbs. Each boiler has its separate smoke-stack, the forward stack casing being arranged as a vent to the galley and the after one as a vent to the firemen's quarters.

Hints on Card Systems.

Card systems are so frequently built up by grafting new methods upon old foundations, that a great deal of practical information may be useless to the individual. On the other hand, a hint may often be developed into a system. A writer in *Marine Engineering* (New York), recommends cards measuring 4 in. by 5 in., both blank and plain ruled, the cards being indexed very simply, according to subject only, with few cross references. To begin with, formulæ for calculation are copied and filed—not standard, well-known formulæ, as for beams or Lloyds, etc., but such useful formulæ as one comes across in good technical reading, or such as one may

THE UNITED STATES TORPEDO-BOAT DESTROYER "TRUXTON."

derive himself. The source of all data should always be given, as data without positive authority for its existence will not be recognised in reputable engineering offices.

Sketches form another important division of the card index system. They may be freehand or scale drawings. In this work the usual mistake is to accumulate too much useless matter at the start. No sketch should be filed unless it has some special or standard point of merit. It is a mistake to sketch everything haphazard. In connection with this the kodak may be used with valuable results. Use a plate or film the same size as the card. The 4-in. by 5-in. is advised for both. Machinery, ships, details, large drawings, methods of hoisting, and interesting accidents can be photographed on the spot, and the print filed with the data on the back. With this data should be given the number and other information necessary to find the negative. A sheet or two of good blue-print paper may be cut up into cards, and on these prints can be made from parts of large drawings which have special features desirable to note, Indicator cards may be taken on thin paper and then printed through on these, to save for future reference. The scales must be measured off and marked before printing, as the blue-print paper will shrink and stretch.

Many times one wishes to keep clippings of drawings or engravings of machinery, fixtures, inventions, etc. One hesitates to spoil his file of papers, and yet hates to buy extra papers to cut up. The following works beautifully: Make a solution of alcohol saturated with clean sal. soda, then add one-tenth, by measurement, of fine, clear, powdered shellac. Spread this solution on the picture desired. Lay a blank card over it, and rub the card with a warm flatiron. Then carefully lift the card. The picture will be beautifully transferred to the card, with still enough left on the magazine to be perfectly clear. Of course it will be reversed, but this seldom matters. By these methods full and very complete data, with photos, etc., may be filed of the building of a ship, her engines, boilers, propellers, tests, materials, and appearance. The full data of her trial may also be filed systematically and clearly.

One can file, for comparison, data pertaining to valve gear, cards, combined cards, various curves, the more abstruse and mathematical data pertaining to a particular piece of machinery, that the designer may have all this to refer to when he has occasion to make comparisons.

Also cards may be cut from cross-section paper, and in miniature these will serve to preserve the curves used in calculations. For instance, the curve of thrust for a given ship is useful to have for comparison with the next ship in order to judge what has been attained in a comparative way.

When one is sightseeing he should be supplied with sketchbook and rule or kodak. Of course, reference is made to sightseeing in the machinery line only, as one of the best sources of information for the card system is what a person sees and hears. For instance, the writer once inspected, and was much interested in, a forced-draught system which an ingenious mill foreman had devised to assist in burning wet redwood sawdust and slabs. The information and remarks were put on one card, a sketch of the tuyeres on another, a skeleton sketch of the piping and blower on a third, and a photograph of the plant on a fourth. From these four cards the plant could be successfully installed by one who had never seen it.

Of equal, if not greater, importance than what an engineer sees and experiences is what he reads. His periodicals, his books, the literature from his various societies, and the great number of handsome, instructive catologues will all furnish valuable material. For example, the various formulæ for flat plates to resist pressure, the standard forms of Corliss gears with drawings, sketches of different systems of oil burning and data, valuable tests of bursting point of flywheels, etc.

The value of advertisements is under-estimated by many. Recently an engineer, on looking in his card system, saw "How to condense with a small amount of water—new idea." Looking up the reference, he found that it was the now well-known system of surface condensing with a spray and blower. The idea he had seen in an advertisement, and it happened to particularly suit the wants of his client, and a neat compensation was his reward.

It can be readily seen that such a card system would take the place of the pocket or note-book. It is not an index system, for it is the note book in itself, and never ceases to grow.

As to methods of indexing, cross references should be avoided except where especially desirable. It is best to arrange according to name of largest conglomeration, as "Steamship *Korea*" or "Waterside Power Station." Then if a man wants, for instance, a good design for 80-inch cast-steel steam piston, instead of looking in "Pistons," he looks under some job such as would be likely to have a piston of desirable design. But if he finds a piston in his travels or readings of peculiar or special merit, then it, with sketch and data, is filed under the head of "Piston."

Cross-section paper cut to card size occupies no mean place in the card index. Curves can be reproduced or data of a run can be thus preserved. Suppose the records of a station are kept on the card index system A card is marked every thirty minutes with the point showing graphically the load, and another point showing the coal or oil consumed. At the end of the watch the cards are turned in to the clerk, who traces the load curve in black and the fuel curve in red, and it is then filed away for reference and comparison, or used by the consulting engineer for comparison with other stations. This scheme can be carried as far into complex detail as may be desired; and the possibilities of the card system are in evidence at their best in just such a place.

The cards are best filed in a fixed cabinet, many ingenious varieties of which are handled by well-known companies.

The first question in a beginner's mind is, "Shall I retain my notebook?" It is not necessary if the card system is carefully classified and labelled envelopes used. These envelopes for indexing can be obtained from any card index company. In them can be kept stray clippings, articles, negatives, samples of emery, polishing compounds, chemical tests, filings, scale, sediment, etc. They should be the same size as the cards, and can be filed right among them.

It is well to have a little morocco case that will neatly hold and protect at least fifty cards, in order that those relating to any given subject or group of subjects may be carried in the pocket for reference when required. Suppose one is installing or figuring to install a centrifugal pump, and has to see the pump or talk with the customer frequently. It would be well to have his available data and former estimates in his pocket, that he might drop into a quiet corner and consult them if perplexed. Memory cannot be absolute.

Large drawings in the engineer's office must be classified with the books and periodicals of which the cards are the index. They can be filed according to any of the approved drawing-room and library systems; but the object of the card system ends with the ability to ease the burden on memory, systematise technical data, constantly eliminate that which is obsolete, and be able to utilise the remainder at a moment's notice and to the best advantage.

Water Tube Boilers.

The report on the trials, under the direction of the Boiler Committee, of H.M.S. *Sheldrake*, *Seagull*, *Espiegle*, and *Fantome* has been issued as a blue book. The *Sheldrake* and *Espiegle* are fitted with Babcock and Wilcox boilers, and the *Seagull* and *Fantome* with Niclausse boilers.

With certain exceptions, no trouble was experienced with the boilers and engines of the *Sheldrake* on the short trials.

The machinery and boilers of the *Espiegle* worked satisfactorily on all the trials, but the safety valves on at least one boiler were leaking during the trial at 1,000 h.p.

The machinery and boilers of the *Seagull* worked satisfactorily throughout the short trials, except that considerable trouble was experienced with the boiler safety valves.

The machinery of the *Fantome* gave no trouble throughout the trials. The boilers also worked satisfactorily, except that on the full-power trial there was difficulty in keeping steam for the power required, and it was considered that this was probably due to soot on the boiler tubes.

Testing Wire Ropes.

The Burgundy section of the *Société de l'Industrie Minérale* has appointed a committee for studying questions connected with wire ropes; and the following remarks were made by the President of that committee, M. de Morgues, in a communication on testing:—

The chief difficulty encountered in the testing of wire ropes is, not the machine, but making fast the rope. Empirical formulæ have generally been employed for determining a rope's strength from knowledge of that possessed by its component parts. A judicious choice from among all these formulæ would be difficult; and the author is not going to propose a new one, but only to seek after a programme of investigation for throwing light on the different conditions under which ropes are subjected to strain. In this connection there are five factors to be considered—diameter of wire, resistance per unit of sectional area, number of deflections, elongation and "cablage" (pitch and torsion).

The author described his compilation of a table recording the results given by the direct testing of twenty new ropes not exceeding 100 tons in total resistance; and side by side with these results he placed those arrived at by means of the various formulæ, showing wide divergence. M. Bouchard followed with some particulars as to the testing machines at Blanzy. Three machines for testing ropes are employed at the Blanzy Colliery—one, of 100 tons, for tensile strains; another, of 25 tons, for tensile strain and elongation; and the third for deflection tests. The first two depend upon the same principle—direct tension, with special means for holding the piece of rope to be tested. One of these hold-fasts is attached to the end of a screw travelling in a fixed nut; and the other is connected with a steel-yard, by means of which the tension effected by the screw is balanced.

In the third machine the deflection tests are made by holding the piece of wire to be tested between two jaws rounded to a 5-milimetre ($\frac{3}{16}$ in. full) radius; and the other end is held in a movable vice, in a plane perpendicular to the line of contact of these jaws, round an axis passing through that line, while a special arrangement permits of reading the number of revolutions made by this latter vice before fracture ensues.

THE COOPER-HEWITT MERCURY VAPOUR LAMP AND STATIC CONVERTER.

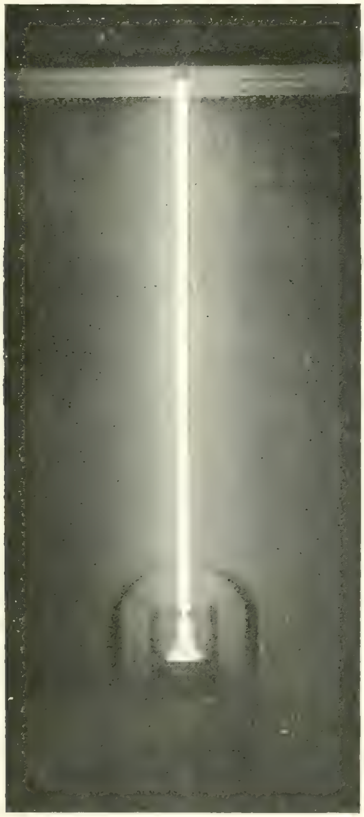
SHOULD the claims made for the Hewitt Mercury Vapour Lamp be substantiated by results in practice, and there certainly seems to be no valid reason why they should not be, the complacency of those who are of opinion that the last word has been spoken in the matter of electric lighting is like to receive a rude shock. For despite certain drawbacks, which are all on the surface, the proved advantages of this lamp are such as to ensure a great vogue for it when it comes on the market. The lamps have now been on exhibition in the London offices of the British Westinghouse Company, in Norfolk Street, since the beginning of the New Year, and at a reception held by Mr. George Westinghouse, on the 9th of January, the principles of operating the lamp, and of the allied invention known as the Hewitt Static Converter, were demonstrated to an audience comprising, among other leaders in the worlds of science and industry, Lord Kelvin, M. Maurice Leblanc, M. Emile Garcke, and Mr. Charles Merz, the well-known consulting engineer.

As may be inferred from the name, the light-giving element in the new lamp is the vapour of mercury. The lamp takes the form of a long glass vacuum tube, with a bulb at one end —those in Westinghouse Building are mostly about 3 ft. to 4 ft. long by 1 in. diameter— exhausted of air and containing only mercury and mercury vapour. Electrodes are fused into the glass at each end, and it is found that, once started, the column of mercury vapour conducts the electric current between the electrodes, and in so doing it is heated to an incandescent state, and becomes brilliantly luminous, the lamp when running resembling a bar of brilliant light.

The most remarkable feature of the new light is its peculiar colour. There is an entire absence of red rays, and in consequence all

WATCHING A TEST OF THE HEWITT STATIC CONVERTER.

MR. GEO. WESTINGHOUSE. LORD KELVIN. MR. CHARLES MERZ (Consulting Engineer, North-Eastern Railway) reds cease to be of any account, and considerable colour distortion is produced; flesh tints in particular assume a curious mottled purplish hue. By the use of certain dye-stuffs in reflectors or screens, or by the intermingling of red lamps, this hue may be modified to a very pleasing colour. Again, experiments have proved that the presence of certain foreign substances in the mercury vapour render the light more agreeable for æsthetic purposes.



THE HEWITT MERCURY VAPOUR LAMP.

The inventor, however, maintains that for a great number of purposes, the absence of red, well-known as the colour most exciting and fatiguing to the eyes, is a distinct advantage. The efficiency of the lamp is at least twice that of the arc, and eight times that of the incandescent lamp; its life is theoretically infinite, but after 1,200 or 1,400 hours the glass usually becomes slightly dimmed, and it is then advisable to open, wash, re-exhaust, and again seal up the tube, after which process it is as good as new. The lamps may be bent to any shape, and may be of any size from 3 in. × ⅛ in. to 12 ft. × 3 in., giving all candle-powers from 10 to 10,000.

Owing to its shape, the lamp emits a remarkably well-diffused light, which does not cast heavy black shadows like the arc. This is of great importance in factories, where it is necessary for the workers to see round their work. It is also an invaluable feature for photographic purposes. Indeed, it is claimed that in some instances, as in portrait work, where the illumination, being constant and, consequently, the exposure nearly constant, the photographer can devote his entire attention to the artistic arrangement of lights and shades, the new light is even superior to daylight. The light is rich in "actinic," or chemical, rays, and has been used with success in forcing plants, in bleaching, and as a germicide.

The allied invention known as the Hewitt Static Converter, which is as yet only in the laboratory stage of its development, depends for its principles of operation on the curious properties of mercury vapour as an electrical conductor, in that it will transmit only unidirectional current. Thus, when connected to an alternating current supply, current passes through in one direction only, the currents flowing in the opposite direction being arrested and absorbing no power. It has long been recognised that the distribution of electric power over large areas is only economically possible by the aid of alternating current, but there are many uses, such as electric tramways and railways, arc-lamps, accumulators, and electro-chemistry, for which direct current is preferable, and in some cases absolutely essential. Hitherto, machines known as "rotary converters," or "motor-generator" sets, have been used for this purpose; both of these are costly and complicated, they require constant expert attendance, and must be installed in specially arranged sub-stations. The Hewitt converter has no moving parts, requires no attention, it is simple, inexpensive, and extremely efficient, the efficiency for ordinary tramway work being about 98 per cent. It can be installed in manholes or pits anywhere, and any number may be operated together. In short, it seems likely that the commercial development of this device will mark a great step in advance in the electrical industry.

MUNICIPAL SOCIALISM AND MUNICIPAL TRADING.

BY

A NORTHERN RATEPAYER

The writer makes out a strong case against Municipal Trading as at present elaborated in some of our large cities.—EDITOR.

SINCE the series of articles in the *Times* on Municipal Socialism began, discussion has become general on a subject which has been exercising the minds of the thoughtful for a long time past. The *Times* did not discover anything that was not previously known to those who concern themselves with social economics, but it brought into general survey matters which had previously been the anxious study of the few. I do not propose to discuss these articles, the matter of which has been already pretty well ventilated and commented on, approvingly and otherwise. They have been accused of having too much special pleading about them; but that is not a just charge. The object of them was to indicate a certain social and economic set of the period, and every incident and illustration was necessary to delineate the situation. There has been, however, a good deal of confusion in the subsequent discussion between Municipal Socialism and Municipal Trading. The terms do not necessarily mean the same thing, although the former almost of necessity connotes the latter. There are certainly many advocates of the municipalisation of industries who are by no means Socialists. And there are innumerable instances of municipalisation which are not the direct result of the efforts of the Socialists or of the municipalisers, but which have simply grown out of local circumstances. Nevertheless, the efforts of the Socialist are plainly to obtain a controlling voice in public authorities, so as to promote the municipalisation and nationalisation of both productive and distributive industries anc agencies. And that way Tammany lies. Tammany means corruption and extortionate taxation.

The gravity of the undernoted conclusions from the facts set forth in the *Times* and elsewhere, cannot be ignored :—

That the unbounded extent to which the principle o municipalisation is being carried by local authorities i whether intentionally so or not, in strict accord with th aspirations of the avowed Socialists in their desire t secure the creation of a Collectivist State, and th transfer to popularly-elected bodies not only of a "public services," but of innumerable trades and a the means of remunerative employment.

That there has already been spread throughout th land, by Socialists, trade unionists, and others, a networ of organisation which aims at either the capture municipalities, or the attainment through them of su ficient power to secure (in the interests of Socialism) a unlimited expansion of the principles of municipalisatio and direct employment, as a stepping-stone to the realis tion of the full Socialist programme, and (in the interes of the Labour movement) the exercise on them of a co trolling voice by trade unionism, with the object making not only the local governing bodies themselve but all business firms having dealings with them, subje to the laws and regulations of the labour unions.

That this network of organisation is steadily widenin its aims and increasing its strength, one of the late developments being an association which is to brin into one body all town councillors and members urban, district, and county councils who are members the Social Democratic Federation, for the purpose extending municipalisation, municipal trading, municip housing, etc., by means of conferences in various tow and an active propaganda controlled from headquarte in Manchester.

That the well-being of British local government, th vigorous assaults by foreign rivals on our industrial a commercial position, and the best interests of the nation at large, all lend emphasis to the demand that carte blanche should not be given to Socialists, semi-Socialists, trade unionists, political agitators, and faddists of all descriptions to exploit municipal government for the furtherance of their own particular schemes or crotchets, the prospect of success in these directions being increased in proportion as the Labour representatives provide well-paid and easy-going municipal employment for those who elect them.

That the Socialist-Labour organisation, which aims at the capture of the municipalities, will also be available, and it is to be used, for political purposes in securing as many seats as possible in the Imperial Parliament, so that, among other things, the Labour members be in a position to overthrow the decisions of Judges in the Courts of law.

That the energy and earnestness of the Socialist Labour party are in marked contrast to the apathy and indifference of the ordinary middle-class citizen.

A FORMIDABLE OBJECTION.

The greatest danger attaching to or threatened by municipal socialism in a nation of representative government, seems to be the bureaucratic one. With an army of employees, every one of whom is an elector, or can influence the voting machinery, there is a power for evil whose potential magnitude can hardly be exaggerated. The creation of a privileged class of public employees is opposed to the comfort and well-being of all other classes. In all the large municipalities there are already enormous numbers of municipal employees whose special interest it is to continue the municipal enterprise in which they obtain employment, whether it is profitable or beneficial or otherwise. As more than one-third of a municipal electorate seldom go to the poll, the vote of such interested employees may at any time decide the issues. In a large number of the populous cities the larger proportion of the inhabitants live in tenements, the rates of which are paid by the landlords. These compound householders do not directly feel the cost of increased taxation, and, therefore, are undeterred by considerations for their own pockets from advocating and supporting any kind of municipal enterprise at the risk of the rates. If the municipal employee were disfranchised, as has been recently and reasonably urged he should be, a certain amount of danger would be removed. But not all, for the compound householder would still be an instrument for the municipalisers' designs. The Committee on Municipal Trading in 1900 heard considerable evidence about the voting power of municipal employees. And it was pointedly urged by some witnesses that any man taking employment under a municipality should not be allowed to vote for municipal purposes whilst so employed. This is not only reasonable, but in just harmony with the principle upon which employers who have public contracts are debarred from membership of municipal and local representative bodies. Whether a Parliament will ever arise to provide this safeguard one canno say, but the absence of it is one of the most formidable objections to the whole system of municipal enterprises, involving the large employment of labour.

EXTRAVAGANCE OF MUNICIPAL TRADING.

It is claimed for municipal trading that it provides or permits of comprehensive treatment, secures the avoidance of the expenditure and waste of effort due to severe trade competition, and establishes a controlling authority to which the consumer can more readily complain when he has a grievance to remedy. I do not attach any weight to any of these claims. On the contrary, there is much less stimulus to economy in management under public than under private control. There is, indeed, a frequent if not a prevailing stimulus to extravagance to do things in a style "worthy of this great community." Then there is the inevitable desire to placate the working-class electors by paying unnecessarily high wages to all industrial employees of the municipality, and to employ as many persons as possible rather than adopt labour-saving devices. There is, further, the conservatism which seems to attach to all departmental institutions, a clinging to the method which is and has been, and to regard with disapproval all new appliances which disturb the current course of operations. Certainly a municipal workshop is the last place in the world in which one would look for the "scrapping" of [illegible] plant, the promptness to do which is among the most lauded of "American method." In all [illegible] and municipal undertakings the disposition is to adhere as long as possible, and usually a great deal longer than is profitable or desirable, to established forms and customs. Besides these disadvantages municipal trading [illegible] grave fault of discouraging and harassing private enterprise — actually or potentially interfered with. As there is now scarcely an enterprise into which some municipality has not intruded, or proposed to intrude, the investment of private capital and cultivation of individual effort are checked in all directions.

VALUE OF INDIVIDUALISM.

The initial and fundamental objection to municipal trading in the abstract is that it is entirely opposed to the system of individualism, upon which the prosperity of the British Empire is based. It is the individual trader—not the State, by protection, or subsidies, or special aids—who has built up our great international commerce. It is the individual manufacturer—certainly not the Government Inspector—who has built up our industrial system to an extent that not even "American methods" or German Imperial industrialism can destroy. We cannot improve the national position by arbitrarily changing the system by which it has been achieved. To replace individualism by Socialism would be to paralyse the energies which have made the nation great. This does not mean, of course, that some matters of public business should not be conducted by the State, either in its Parliamentary or municipal aspects. One recognises the telegraph system, for instance, as a proper form of State enterprise in this country, although in America the telegraphs are worked, as they used to be here, by companies, which is to say, by private enterprise. One admits the provision of water and of gas to be permissible subjects for municipal enterprise, although in the majority of cases both gas and water are provided by companies. Yet, even with regard to these the municipal function is not beyond dispute.

LEGITIMATE AFFAIRS FOR MUNICIPALITIES.

One can hardly draw a broad and general line beyond which municipal enterprise should not go, because local circumstances differ so much. What would be undesirable in most cases may become indispensable in some particular case. Glasgow, for instance, was compelled, as a municipality, to seek a supply of water in a Highland loch, and to construct a vast line of aqueducts to bring it to the city, but it does not follow that every municipality should establis and maintain its own water supply. At th same time, there is this to be said of water as gas, that each is a necessity of modern industri as well as social life, and that the welfare the whole community depends upon the suppl being brought within the reach of all on th least onerous conditions. The community mus have street lighting for police purposes, an abundant water for sanitary purposes, an therefore the supply of both by the municipalit is justifiable, and is often indispensable. Of th product of any enterprise undertaken by municipality, it should be evident that it necessary to, and used by, the whole body those who have to pay the rates. It may b said of gas, of course, that many people do n use it, and that most can do without it if the please. But this applies to household consumption only. For the lighting of streets and publi places it is necessary to the security and comfort the inhabitants as a whole. Therefore, the utilit belongs to the whole community. Then ga making is a steady and a lucrative busines when carried on on a large scale, and as gas i necessary to the life and social order of a tow it is not unreasonable that a municipality i making gas for its own use should give th ratepayers the benefits of the profits of production in lower gas rates. While, however, gas making is a justifiable, and may sometimes be necessary form of municipal enterprise, it is no by any means necessarily so, and towns can be and are, as well and economically served b private enterprise as they could be by municipa management. The only thing of which on could say without reservation that it is a indispensable subject for municipal enterpris is—sewage. In this country, at any rate, th collection and disposal of sewage by privat enterprise would end in hopeless and dangerou inefficiency; yet there are places in Americ where even the sewage system is managed b companies.

PROFITS AND LOSSES.

It has been suggested that municipal enterprise may in turn be checked by lessenin the borrowing powers of municipalities, and b forbidding them to trade for profit. But it i questionable if the borrowing powers of grea and growing communities can be arbitrarily limited. The rapid growth of municipal debt is not a good thing, but neither would be the crippling of the municipal spirit. If the borrowing powers of municipalities are too severely limited they will neglect or curtail expenditure on matters which they should attend to.

Then, again, as to trading without profit. No undertaking can be carried on without profit, except at a loss. You cannot debar a municipality from working at a loss, and therefore you cannot prevent working at a profit. If all profit is to be annexed by the ratepayers in reduction of rates the consequence will be a very unequal distribution of benefits. If, for instance, profits on the gas supply are paid over to the rates, then the large consumer of gas, for industrial or other purposes, is practically helping to pay the rates of the small consumer, who may nevertheless be a much wealthier man. This is saddling the individual with an unjust proportion of the burden of the community. If, again, a municipal undertaking is carried on at a loss—say a tramcar or a telephone service, or a gas or water supply—that is unjust to the ratepayers, because it is making them pay for non-commercial benefits enjoyed by others. In the case of the Tunbridge Wells telephones, the Corporation of that town decided to abandon the system as a municipal enterprise when it showed a loss, because that loss had to be made good out of the rates. But what would they have done had there been a profit? And what will Glasgow do if its much more extensive municipal telephone system results, as is anticipated by close students of the conditions, in substantial loss? The mention of Glasgow recalls the interesting fact in municipal trading that this city is authorised by Act of Parliament to make good any loss on the municipal telephones out of the rates, but is forbidden by Act of Parliament to so make good any loss that may be made on the municipal tramways, or to apply any profits from the tramways to the reduction of rates. The two provisions are inconsistent, but are explainable on the ground that in Glasgow the tramways are not regarded as the property of the Corporation, but as belonging to the common good, or capital property of the burgesses, not the ratepayers. This is a municipal technicality which the plain man cannot easily follow.

GROWTH OF MUNICIPAL TRADING.

It is exceedingly doubtful if any law forbidding municipalities to trade at a profit could be enforced. Besides, in the complications of municipal book-keeping it would be as easy to conceal a profit as it is to conceal a loss. And look at the list. It is now the usual thing for a municipality not merely to equip but to operate its tramway system, and that brings in such allied undertakings as car factories, brass foundries, engineering shops, the manufacture of engines, dynamos, electric fittings, etc. The provision of the gas supply has, in some cases, led to the manufacture of gas fittings and stoves. Municipal telephones are extending, notwithstanding the avowed loss in Tunbridge and the suspected loss in Glasgow. One finds up and down the country municipal undertakings for the supply of cold air storage, Turkish baths, ice, milk, and cycle tracks. One finds municipal concert rooms and lecture halls, municipal hotels and restaurants, municipal shops and lodging-houses. Municipal collieries have been proposed for Glasgow and some other towns. And there are projects, some of which may, perhaps, have already been put into effect, for municipal banks of deposit, municipal notes of currency, municipal fire insurance, municipal bakeries, municipal pawnshops, and municipal drinking bars. We have not exhausted the list by any means; Glasgow, for instance, has gone the length of providing and maintaining municipal golf courses; but we have mentioned enough to indicate the complexity of the situation.

On this point note the following extract from an article in the *Edinburgh Review*:—

> The satisfaction which municipal authorities have felt at the performance of their duties has led to a desire for further responsibilities. Attempts have therefore been made from time to time to obtain an extension of the scope of municipal undertakings in directions which are far more open to criticism than the provision of gas, water, locomotion, or light, or the rendering of services connected with local government. By an Act [illegible] power was given to a Midland corporation to provide Turkish baths. In 1900 power was sought, among other things, to provide apparatus for games and [illegible]

be used presumably, but not necessarily, on recreation grounds established by the authority. In another, power was sought to provide refrigerators and cold ice stores for the preservation of marketable articles, and to sell ice. In another it was proposed to provide bathing tents. In another tailoring was contemplated ; saddlery in another. In several, power was asked for to construct and manage refreshment rooms in parks. By many corporations the power of manufacturing, as well as supplying, electrical fittings was demanded, and in three cases efforts were made to acquire the privilege of providing entertainments and charging for admission.

But there have since been even wider attempts than these made by municipalities to increase the province of industrial enterprise.

DEPARTMENTAL RIVALRIES.

There are comicalities about municipal enterprise which afford cynics a grim satisfaction at times. A house divided against itself is as nothing to the rivalries, disputations and obstructions of competitive or envious departments of the same municipality. In Glasgow one has heard of the head of one department half drowning with the municipal hose-pipe a body of municipal workmen sent by another municipal department to do municipal work near his municipal premises, to which he objected. One has heard, also, of the bitter cry of the residents in the Second City at the successive tearing up of the same thoroughfares by different departments, the one just waiting till another relaid the street before ripping it open again. Then, in Leeds the other day, one corporation department summoned another for permitting its servants to break the Corporation bye-laws. The magistrate (not a municipal one), who gave judgment in one of these cases, said :—

> It is here alleged that officials of the local authority have deliberately directed those over whom they exercise control to violate the very laws of which a printed copy has been supplied for their instruction and guidance. If this be so, it seems to me that no language can be too strong to condemn the action of those who have incited, nay directed, the men to commit open and flagrant breaches of the law. If such a thing were to be tolerated we should have a combination, or blend, of municipal government with municipal trading which might be aptly described as municipal chaos.

Even in double-dyed municipal Battersea the municipal council prosecuted itself for allowing municipal black smoke to come out of municipal chimneys belonging to the municipal electric works, as proved by a municipal inspector.

HOUSING THE POOR (?).

Perhaps in no branch of municipal enterprise has there been more agitation of late than in that of house building. All over the country a movement has spread for the better housing of the poor. The object is admirable, but then nobody knows precisely what it is. Who are the poor ? Where does the line of social demarcation exist beyond which provision ought to begin ? And who are the proper providers ? These questions are unanswered, and in present lights are unanswerable, but nevertheless numerous municipalities have addressed themselves to providing houses of sorts for people of kinds, but not of the kind who are unable to find dwellings for themselves. Glasgow has pulled down old houses and built new ones, but the new houses are not occupied by those who have been proud of the old ones. And so elsewhere. Apart from the unsolved problem of whether any class ought to be provided with houses (any more than with coats or dinners) from the municipal purse, and what that class is, the building of houses by municipalities has been at a higher cost than by individuals. A municipality cannot build as cheaply as a private builder ; even by contract it lays down regulations and restrictions which add to the cost. The London County Council has built dwelling houses at a cost of £230,000, which are only valued at £95,000, and the rents are too high for the people for whom the houses were supposed to be provided. Liverpool has spent two millions in building dwellings for people who do not occupy them, because they are either too dear, or in other respects unsuited to the needs and desires of those unhoused from the old dwellings. In other towns municipal dwellings have been erected which cannot be maintained on the rental, and which, therefore, form a charge upon the rates. The housing problem, however, is too large and complicated for discussion on a side track of the general line of this paper. What I would point out is, that without understanding its conditions the municipalities are attempting to solve it in the wrong way, and by their ill-directed efforts are checking the enterprise of semi-philanthropic private companies, which were doing excellent practical work in their own way, and for a bare margin of interest.

MUNICIPAL LIABILITIES.

The enormous growth of the local indebtedness of the country has been characterised as a danger to the finances of the country. If this seems an exaggeration let it be remembered that this local debt is rapidly assuming the dimensions of the National Debt. A large portion of it, no doubt, has been incurred in respect of what are called remunerative undertakings, that is to say, municipal enterprises like water, gas, electricity and tramways, that yield, or are supposed to yield, a profit on the working. But then the term also includes telephones, buildings, and other enterprises which do not, and probably never will, yield a profit. It is a point to be noted that rates have increased rapidly along with the development of so-called "remunerative undertakings." And it is also a point to be noted that municipal bonds have not appreciated in the estimation of the investing public, probably because of this progressive increase in rating which, if prolonged, must lead to the depreciation of the rateable area. Overtaxed manufacturers and private residents can at all events remove their factories and their households to cheaper environments, and this does not make for the security of the rates against loans. If the great financial institutions of the country are not very eager to invest in municipal bonds there must be a reason for it. And the reason is that municipalities are investing too much in hazardous undertakings, and by so doing are menacing their own main sources of revenue and security—the ratepayers. To avoid or postpone the issue of loans, some of the municipal bodies, like those of the London County Council, Liverpool and Glasgow, raise money from time to time on their own notes of hand, or bills, at six months and other dates. This is a simple and easy way of financing when the money market is easy, but what of times of financial crises? These bills are issued to suit the momentary requirements of the municipal borrower, without consideration of the present and future of the money market. Any year they may mature at a time when they can be neither retired nor renewed. And then would result panic. The scheme of finance adopted needs an expert banker or financier to manage prudently, not an ordinary municipal treasurer, who knows little or nothing of the intricacies of the money market, and the influence of exchanges.

BURDEN OF THE RATEPAYERS

Municipal rating has doubled within the last quarter of a century, and the greater part of the increase has been in the last ten years or so. In 1875 the local debts amounted to £92,820,000 In 1901 the amount was £330,000,000. In 1875 the rate of municipal debt per head of population was £3 18s. 3d.; in 1900 the proportion was £9 4s. 4d. Between 1875 and 1900 the National Debt was reduced by £139,966,000; but in the same period the local debt was increased by £200,000,000. In the last six years of the decade ending in 1900 the local borrowings were about one hundred millions sterling. And of the total outstanding amount of local loans it may be said that fully one-half are for purposes in no way of the "productive" order, but to a large extent for undertakings of a hazardous or speculative character. Sir Henry Fowler demonstrated to the Royal Statistical Society some time ago, that on municipal undertakings, for which eighty-three millions had been borrowed, and which yielded an income of something under nine millions, only one-eighth per cent. had been set apart for depreciation, and the net average annual profit was only about one-half of one per cent. on the borrowed capital. That is to say, they were really being conducted at a loss in the aggregate, for one-eighth per cent. is not a commercial allowance for depreciation. The investment has been much larger since Sir Henry Fowler's scrutiny, but not the profit, so far as one can gather. And private enterprise has not been encouraged, but checked, during recent years by municipal interference, as well as by severe foreign competition. During the last five and twenty years or so the local rates in England and Wales have risen on the average from 16s. 2d. to 25s. 7d. per head of population per annum, while the rateable value has increased by over 50 per cent. To put it otherwise, a good deal more than twice as much as was raised from local rates in 1875 is now being raised, although the local exchequers are receiving over ten millions per annum more from the Imperial taxes than they did in the former period. Whatever benefits may have accrued from municipal trading in these twenty-five years, they have plainly been obtained at an enormous actual cost, and an enormous addition to the burden of debt upon the body of ratepayers.

CONCLUSIONS.

The following items from the *Times* summary of conclusions are very much to the point :—

> That while, in the case of some of the large towns or elsewhere, muncipal undertakings may be profitably conducted along wise and efficient lines, municipal enterprise generally has been carried to excessive lengths, especially in the case of smaller communities, or those where there is a lack of capable business men on the local body, with the result that, as declared in the *Accountant* of September 27, 1902, "many of the trading departments owned by local authorities, which year after year are being made to show profits on trading, are practically unsound, and must, if matters are allowed to pursue their present course unchecked, inevitably, in the course of time, end in utter collapse.
>
> That the direct effect of unrestricted municipal enterprise on British industries is a matter for serious consideration, the results being especially experienced on the following lines : (*a*) Absorption by municipalities of industries previously left in the hands of individuals and companies ; (*b*) Competition with private traders in industries which the latter still seek to carry on ; (*c*) Influence of municipal action in checking invention, industrial progress, and independent effort ; (*d*) Pressure of increasing rates on industries where foreign competition has to be met, and cost of production should be kept to a minimum ; (*e*) Injury done to the interests of a large number of professional men—architects, engineers, and others—by the multiplication of public officials who readily undertake a variety of schemes or designs, requiring a high degree of technical skill, whether they are really capable of dealing with them or not, thus depriving the said architects, engineers, and others of a considerable proportion of their legitimate business ; and (*f*) Prejudice to the building and other industries by reason of direct employment.

Apart from the question of finance, the extension of municipal trading is to be opposed on account of the dangers of the bureaucratic result referred to earlier in this article. The duties of municipal corporations are to supervise and control the affairs of the whole community, not to enter into competition with any section or classes of it. Only when private enterprise fails to supply the public needs in any service should the municipality become purveyor. It is proper that an urban corporation should lay down and control the tramway track within its area, because a public authority should have command of the thoroughfares ; but it is not therefore desirable that a corporation should operate the tramways, which private enterprise can do much better. It is, further, wholly unwarrantable for any municipality to use the whole public funds and credit in any enterprise such as serves only a small proportion of the community—as for instance, telephones. And it is both improper, unjust and impolitic for any municipality to enter upon any industrial or trading undertaking in which private enterprise is already engaged, such as building, baking, banking, tailoring, etc. The duty of a governing body is to govern, not to trade.

THE COOLGARDIE GOLDFIELDS WATER SUPPLY.

BY THE

WEST AUSTRALIAN CORRESPONDENT OF "PAGE'S MAGAZINE."

The author gives details of the scheme designed to supply the town and mines of Coolgardie with a permanent water supply. He shows the exceptional nature of the district's requirements, describes the methods employed, and incidentally deals with the special difficulties encountered in the execution of the work now just completed.—EDITOR.

PERTH, *December 20th*, 1902.

ALREADY gold mining had been carried on at Southern Cross when, in 1892, some prospectors, following out Hunt's track, camped on the present site of Coolgardie. Next morning, while they were saddling up, Bailie and his companion rode up, and while talking to the departing party noticed one of the horses kick up a nugget of gold.

A search instituted after the departure of the prospectors revealed a seam of rich gold, and led to the famous Bailie's reward claim, which opened a new chapter in the fortunes of Western Australia.

The approaching summer drove prospectors coastward, but only to wait for the winter of 1893, when hundreds rushed to the new finds, returning again to summer in the settled portions nearer the coast. A few, however, braved the coming summer, many of the latter being rescued from perishing by the blacks.

SUPPLY FROM CONDENSERS.

In the earliest days half a crown per gallon was the ruling rate for water, and the man who could always obtain sufficient to assuage his thirst was considered lucky, for frequently the precious fluid was doled out in small quantities.

The advent of the condenser soon produced a reliable water supply at rates varying from 6d. per gallon, until about 1897 nearly all the large centres had condensers delivering water at 25s. to 30s. per hundred gallons.

GOVERNMENT ACTIVITY.

Realising the importance of the new industry to the country, and the number of lives risked, the Government threw red tape to the wind, and displayed astounding energy. Borings were made, wells sunk, rocks walled in, and the water led into dams, and tanks. Condensers were erected where salt water could be found, and water was even packed on camels to succour prospectors trying to get back from outlying rushes.

SCHEME FOR PERMANENT SUPPLY.

After the construction of the tanks months passed before rain fell, and then, owing to a peculiar perforation in the apparently clayey ground in which they had been sunk, much of the first catch was lost. Sir John Forrest, then Premier of the Colony, instructed the Engineer-in-Chief, Mr. O'Connor, to formulate a scheme for the permanent and certain supply of the town and mines at Coolgardie.

SELECTION OF A SOURCE.

On inspection, no large catchment areas could be obtained locally of which a run off could be anticipated. No natural storage was procurable, save shallow depressions, and had any been obtainable the rainfall was small, and of doubtful regularity. Mr. O'Connor, therefore, selected as the source of the supply the valley of the Hellena, in the Darling Ranges, where the gathering ground could be reckoned in hundreds of square miles, and the storage capacity in hundreds of millions of gallons. Here, also, the records showed a known average rainfall of about forty inches on the Western slope and about fifteen on the Eastern side.

MAGNITUDE OF THE SCHEME.

The real magnitude of the work was involved in the conveyance of the water from a district of known rainfall across the intervening 350 miles to the centre of consumption, which also is more elevated than the source by over a thousand feet. The estimated cost of two and a-half millions sterling, as the capital cost of the undertaking up to its discharge into the service reservoir about eighteen miles from Coolgardie, does not appear a large sum; nevertheless it was held out as an insurmountable obstacle, and, indeed, it was a great undertaking for a people then only numbering some 70,000 souls, upon whom already rested the responsibility of several great public works.

Owing to the growth of Kalgoorlie, and the consequent extension to that town, and many other new items, the original cost will probably have to be exceeded, but even then the outlay will be small compared with the benefit to be derived.

But for the indomitable energy and strong personality of its founder, Sir John Forrest, the scheme would have perished at its birth. Many considered that the maximum borrowing power of the Colony had been reached, if not surpassed. Some opposed it because it was put forward by the Forrest Government, and others because it was not an exact copy of what had already been done elsewhere. However, the Bill was got through in time to meet the great slump and commercial panic of 1897-8.

About this time mining script fell very low, and many of the bogus mining properties, floated by unscrupulous persons, collapsed, causing quite a slump in everything West Australian. The vigorous public works policy was suspended, flooding the labour market with those who had been engaged thereon. Any who could afford it left the Colony, and, as a consequence, the building, plumbing, carpentry, brickmaking, timber and allied trades received a sudden check that fairly staggered the country.

BORROWING POWERS.

In estimating the borrowing power of a Colony the ordinary policy is to compare it *per capita* with the National Debt of the United Kingdom. That this is wrong in principle should be self evident. The British National Debt may be considered a war debt—that is, the principal has to all intents and purposes been blown away in smoke, and is absolutely lost, and interest has to be paid on a loan from which we derive no direct revenue. The West Australian loans, on the contrary, have been invested—more than 50 per cent.—in railways, which item could alone be sold for more than the total indebtedness. Large sums are also invested in harbour works, telegraphs, telephones, water supplies, public buildings, etc. The last-named do not, of course, yield a direct revenue, but add to the wealth of the nation, whereas the former pay working expenses and interest, and were it not that they are intended to develop the country, and furnish transit, communication, etc., at a very low rate, a sinking fund could be provided that would in a few years repay the principal.

THE SCHEME STARTED.

In spite of the fact that the Bill was launched at such an inopportune moment, the Ministry, in the face of powerful and keenly antagonistic opposition, determined to start the work and carry it on at all costs. It was very properly considered to be essential to the well-being of the community situated on the gold fields, for families cannot live with comfort in a hot climate when water costs £10 to £13 per hundred gallons, or even at the existing rates of £8, whenever the Government dams are dry.

Work was at first started in a very small way, such as clearing timber on the reservoir area, etc. Later on the excavation for the dam was put in hand, and, as soon as possible, contracts were let for cement, and for the pipes and pumps.

When a large project is undertaken on the strength of a very slender majority, the lot of the Executive is not a happy one, but it was noticed that with the progress of the work the opposition grew perceptibly weaker.

FOUNDATIONS FOR THE DAM.

The rock was stripped under the seat of the dam and all loose or broken stone removed. Then it was discovered that a fissure underlay the river bed, in fact, by costeaning, it was discovered to be present for many miles both up and down the stream, pointing to the deduction that the Hellena had formed its valley along the fissure.

After removing all drift, debris, shattered rock, etc., the filling appeared to be impervious, but in case the crack had at any time been opened out and refilled, perhaps with gravel or boulder beds coming to the surface, somewhere up stream, the Department determined to continue the excavation until the walls came together. Consequently, whether hope rose as the reef narrowed to a couple of feet or fell as it widened to eight or ten, work was steadily carried on, until about a hundred feet below the river bed the solid rock wall gradually came together until within half an inch. To this depth, then, an excavation was made in the solid granite or harder even trap dyke that traversed it. The crack, which rapidly dwindled to practically no width, was cleaned out and filled with cement grout, and the whole of the excavation filled with cement concrete.

Undoubtedly it was a wise policy to guard against leakage along the fissure, besides making sure of a solid foundation for the superincumbent masonry, but would not a shaft sunk to the same depth at each toe of the weir, or to the same depth at the up-stream toe, and filled with concrete, have insured against leakage; and an excavation, say twenty feet deep beneath the down stream toe, and water cushion, etc., filled with concrete, might have proved a complete guard against undermining by the occasional overflow.

An arched formation could have been given to the concrete, throwing the strain on to the solid rock on either side of the fissure, so that, if the reef proved more compressible than the adjoining granite, cracks should not form in the dam. In the existing circumstances it is more than likely that, owing to the greater shrinkage of two hundred feet of concrete, than of the one hundred feet adjoining, two small vertical cracks may form in the masonry, and had the deep foundations been of a great width, instead of being narrow, two visible cracks would undoubtedly have formed. Such cracks, although unimportant in themselves, would be disagreeable from the moral sense as furnishing a bone of contention for amateur critics and interested persons.

The danger of large cracks has, however, been minimised by the gradual battering back of the side slopes, and the authorities have the satisfaction of knowing that the fissure has been filled with a reliable material.

TEMPORARY DAM.

Before starting work it was necessary to build a small temporary dam, a few hundred feet above the actual site to impound water for the summer supply; and to divert the flow into a flume, carried clear of the excavation when the river was running.

CEMENT AIRING SHEDS.

The cement to be used for the concrete was discharged from the trucks into the airing shed, where it was opened and spread on the floor, which was made of strips "*en bascule*," which, when triped, let it fall on to a similar floor at a lower level, and by repeating the process the cement was thoroughly mixed and aired with a minimum of labour.

CONCRETE.

Granite, quarried from the foundations, supplemented by stone obtained close by, was conveyed in trucks and discharged alongside the Gate's crusher, a couple of men throwing it into the bell mouth as the machine treated it. It then went down by gravitation to the mixer. The cement, sand, and water were added from automatic feeders, the whole being thoroughly mixed in a revolving inclined drum furnished with baffles. The drum discharged into wheelbarrows, in a procession of which the concrete went to its destination.

THE RAILWAY.

One of the earliest works undertaken was a railway about six miles long running down from Mundaring Station, on the Eastern line, to the reservoir site, and zigzagging down the side of the valley to the pump house. This line destined in the future to convey coal to the pumps, has proved a great boon in conveying cement, sand, machinery, pipes, etc., across the rough mountainous country at a minimum of cost.

PIPES AND PIPE MAKING.

Where the materials have to be transported great distances, cast iron pipes have the great disadvantages resulting from volume and weight, not to mention brittleness; consequently, it was decided to adopt steel pipes with an internal bore of thirty inches.

The design of the pipes is practically new, and is patented by the firm of Mephan Ferguson, of Melbourne, and, as far as can be judged, no better or simpler form of wrought pipe has yet been invented.

The two firms who obtained contracts for the pipes established local works, where they manufactured the finished article from the imported plates and bars.

The pipes are thirty feet long, are tested to 400 lb. hydraulic pressure per square inch, when uncoated, and do not contain a rivet.

With the exception of slight differences in machinery the process at both works was practically the same.

A plate was picked and placed on a table over which a gauge was suspended; this was let down on top of the plate, and the four corners marked. A traveller then conveyed it to a machine, which shored off the ends, leaving them straight and true to length. The plate then proceeded to a machine, in which it was clamped, while a paring machine, with a succession of cutters, travelled along it, leaving the two edges planed and the plate of the correct width. The cutters were followed by rollers, travelling above and below the plate in conjunction with rollers running along its edge, each set squeezing the material a little more than the previous set, so that the steel plate left that machine with its edges dovetailed.

As the plate passed along the workshops it went through a machine, in which a ram rose buckling the plate slightly; it then passed on to a machine consisting of three rollers, between which it was rolled until it curled up like a collar, remaining straight throughout its greatest length and taking a semi-circular cross section.

The plate was then laid on the floor concave side up, an H bar laid on each edge, and a second bent plate let down on to the upturned grooves in the H bars. A number of collars were then put round the embryo pipe, which was then picked up by a traveller and pushed endways through a machine, in which a ram rose and pressed against a foot at a time of the lower H bar squeezing it against a die, held in position by a long trellised arm, which communicated the pressure to the upper H bar, which, in its turn, squeezed against a die in the upper part of the machine. Thus, at each blow of the hydraulic ram, one foot of each of H bars was pressed home upon the dovetailed edges of the semi-pipes, until they resembled two oval bulbs running one along either sides of the pipe. On leaving this machine the spare ends of the locking bars were shorn off, and the pipe rolled down to the tester, whence, if the trial were satisfactory, as was usually the case, it rolled on to the coating baths.

DISTRIBUTION OF PIPES.

The pipes being finally ready, were loaded on trucks, usually six per truck, taken out in train loads and distributed along the track, which, for the greater part of its length, lay within the railway reserve.

PIPE LAYING.

At one time it was proposed to lay the pipes on the surface, but several serious drawbacks presented themselves to such a procedure. In the first case, in a climate where the temperature varies between 20° F. and 180° F. in the open, with frequently a diurnal variation of 110° F., contraction and expansion become very serious items, and expansion joints would be necessary to prevent the line assuming a serpentine course, and the drawing of the joints. Again, in summer time the water would reach its destination in an unpleasantly hot condition, and the same season is favourable to the growth of a white stringy weed, which would tend to raise the resistance to pumping and diminish the flow. These considerations led to the burying of the pipes in trenches.

PIPE TRENCH.

The pipe trench was taken out for almost its entire length in the early days, while the undertaking was still encumbered with difficulties, and, later on, a gang ahead of the pipe layers trimmed, graded and took out the manholes.

This so-called coming back on the work gave rise to a good deal of adverse criticism in the press, but it would have been a doubtful saving to have taken the manholes out originally, for it would have taken very accurate measuring and knowledge of contingencies to keep them evenly at the joints thoughout 350 miles. But, even with the best of supervision, some loss of time, through shifting and, occasionally, through loafing, is bound to take place on a long straggling job, such as the excavation of a pipe trench.

LEADING AND JOINTING.

The pipes were run over the trench on skids, in which were set rollers, the first having its axis parallel to the skid, and the other two rollers had their axes at right angles to it. When on the first rollers the pipe could be moved readily lengthwise, and thus adjusted for position, it was then rolled a little further on to the two transverse rollers, over the centre of the trench, and rotated until the two bulbs formed by the locking bars were at the same elevation. A pair of light shear legs were thrown over the trench from which wire ropes lowered the pipe into position after it had been temporarily suspended for the withdrawal of the skids.

A ring or thimble formed the jointing piece, and, before lowering a pipe, a ring was pushed right on to the end of the previous pipe, and, as soon as the fresh pipe was in position, butt to butt with the last one, the ring was slid so as to overlap each pipe equally.

A man travelling inside with an expander pushed it over the joint and expanded the union screw, joining the two halves of his wheel. This served the dual purpose of making the two pipes join perfectly, and preventing any lead from running into the pipe.

A number of leaden wedges were inserted under the rings to keep the opening uniform around the pipes. Leading belts were fixed, and the lead melter, which consisted of an oil furnace travelling on top of the pipe, was drawn forward on to the joint and the lead run—the whole process taking less time than it takes to tell.

Following the leader came the caulking machine. This consisted of a series of rollers running on the lead on both sides of the ring, and compressing it, very much after the style of the dovetailing rollers already described for the steel plates.

The rollers were drawn round a rack, worked by an electric motor, and squeezed up the lead At the last round a cutter was added which trimmed off any lead that had spued beyond the ring. Owing to the bulbs formed by the locking bars, the machine had to be reversed at every half revolution, and the portion round the locking bars hand caulked. Had it been possible to run right round the pipe, the working of the machine would have been simpler and cheaper.

The use of the expander obviated the necessity for gascut, though probably no part of the scheme gave rise to more criticism than this labour-saving machine. Hostile letters, originating with the labour movement, were written, and the papers soon teamed with an abusive correspondence, the department as usual remaining mute.

THE LATE ENGINEER-IN CHIEF.

No paper on this subject is complete without a reference to the sad death of its leading spirit, Mr. C. Y. O'Connor. His counsel, wisdom, and many good qualities were widely appreciated, and his demise, prior to the completion of the work, was regretted by all.

THE ENGINEERING TRADE AND THE PREMIUM SYSTEM.

BY

A WORKS MANAGER.

The author carefully describes and compares the three prominent systems which are now before Engineering employers.—EDITOR.

THE NEW AGREEMENT.

THE main feature of the premium system is that it makes a division of the savings, due to increased production, between the employer and employed by a direct method, instead of by the circuitous method of profit-sharing. The principle in brief is this: The time required to do a certain piece of work is known by experience; and the workman is offered, in addition to his ordinary daily or hourly wage, a premium for every hour by which he reduces that time on future work. Mr. F. A. Halsey, of New York, claims to be the first inventor of a plan for payment of labour in which the gains due to increased production by a workman are divided between the workman and his employer, but there is reason to believe that some such plan was in operation long before Mr. Halsey's time. Mr. Rowan, of Glasgow, was the deviser of a system which underlies the basis of the agreement recently made between the Engineering Employers' Federation and the Amalgamated Society of Engineers. Touching the rate of premium, Mr. Halsey has written: "For this there is a perfectly clear principle to guide us, and that principle is precisely the one which we use in buying anything whatever with money, viz., to pay what is necessary to get what is wanted, but to pay no more. If we have a fence to paint, a roof to shingle, the only principle we ever think of following in order to get the work done is to pay enough to induce someone to do it. If we offer less than that, the work will go undone, while if we pay more the surplus is a simple gratuity. So here; a workman has been working at the usual pace and has been paid the usual daily wages; if we wish to induce him to do more we should offer enough as a premium to induce him to make the extra exertion, and no more. If we offer too little he will reject it, the offered returns being too small to recompense him for the effort, and the desired increase will not be obtained. On the other hand, if we offer too much, the surplus, as in the case of painting the fence or shingling the roof, is a simple gratuity." There can, therefore, be no simple premium rate to apply to all classes of work, and certainly not in machine shops where increased output is so much a matter of intelligence.

THE NATURE OF A PREMIUM.

It is unfortunate that the term "premium" should carry with it the idea of gratuity, because the payments in the premium plan are in no sense gratuities, or bonuses, but actual earnings. They are special earnings on the increased industry of the workman. With a proper adjustment of rates to plant and methods of production there is established what Mr. Halsey calls "a condition under which and under given methods of production we will obtain the highest possible production and the lowest possible cost, while the workmen will receive the highest wages to which he is economically entitled." The premium plan systematises the practice under which an employer pays higher wages to efficient than to inefficient workmen. It grades and recompenses men according to their efficiency, but the efficiency cannot be procured without the payment. There are various methods by which the premium system can be administered, but the principle must always be that of dividing the gain through efficiency, so as to encourage the workmen to greater vigilance and special industry. It starts upon the basis of weekly wages for ordinary work, plus a bonus for speedier production. There are three prominent systems now before engineering employers—that of Mr. Halsey, that of Messrs. G. and J. Weir, and that of Messrs. David Rowan and Sons, of Glasgow.

THE PREMIUM SYSTEM IN PRACTICE.

The system of Messrs. G. and J. Weir, of Glasgow, was organised as a result of their belief that in an engineering works which has for years worked only with time wages, the relative wages do not represent the relative values of the men. To remedy this it was decided to adopt the premium system because it is simple and easily understood by the men. It is simple in its application, and needs very little addition to the clerical staff ; it has not the defect of piece-work, in which an error in rate-fixing is either expensive or discouraging; it offers an inducement to the workman to suggest improvements in tools or machines ; it affords accurate data for time-keeping and cost-keeping purposes. After three years' trial Messrs. Weir were able to report that they found the following among its many advantages It resulted in a largely increased output from their machines. It increased the average earnings of their workmen from 10 to 40 per cent. It practically compelled maintenance of their machines in the highest state of efficiency. It greatly increased the interest of the men in their work, and in the plant, and promoted a fair amount of co-operation in all the firm's schemes for improving the factory. It gave the foremen a field for the choice of men they had not previously before them. It caused the foremen to be no longer task-masters over the men, but providers and inspectors of work for them.

THE CONSIDERATION OF WORKMEN'S SUGGESTIONS.

Messrs. Weir also inaugurated what is called the "Friction Club," a body composed of the foremen and administrative heads of all the departments, for the purpose of securing proper discussion of shop problems, and to assist in the provision of machinery for the systematic carrying out of suggestions, and for reporting results. The club has dealt with such matters as the establishment of a works library ; a workmen's suggestion scheme ; the admittance and course of apprentices in the works ; the lighting of the shops ; the distribution of shop labourers ; shop hindrances, as reported by the several foremen ; and so forth. This club promoted and inaugurated the "Workmen's Suggestion Scheme," an arrangement to encourage the workmen to make suggestions for improvements in the shops and on the work. A box is provided into which a workman places a memorandum of any suggestions he has to make, putting his name and shop number on the paper. These suggestions are read and discussed at the Friction Club, where the award which should be made on the merits of a suggestion is also indicated. This has been found to be an educative and useful arrangement. A Technical Committee, composed of the managing director, the shop manager, the chief draughtsman and special draughtsmen, deals with revision of designs, experimental work, the tabulation of results, the consideration of defects, the criticism and development of new designs, etc. These schemes, of course, are not part of the premium plan, but they combine along with that plan in bringing masters, managers, and men, into direct personal and friendly relations. Under Messrs. Weir's plan, the saving effected by a workman on the allowed time for doing a job is divided half-and-half between the man and the employer. That is to say, if a job is timed for twelve hours, and the man does it in eight hours, he is paid for two hours in addition to his weekly rate on the job.

Mr. Halsey's plan is rather to keep a good weekly rate, and to give as premium one-third of the time saved.

THE PREMIUM SYSTEM IN MARINE ENGINEERING.

Until the engineering strike of 1897-98, it had been regarded as impossible to introduce piece work into a marine-engine factory, on account of the great variety of work. But during that strike a premium system was established by Messrs. David Rowan and Sons, Glasgow, who make nothing but marine engines. It is this system which, varied according to circumstances, will be applicable in other departments of the engineering trade under the agreement which has now been effected. That agreement, of course, is merely permissive, not obligatory.

The following is Mr. Rowan's method of working the premium system :—

When work is given to a workman on a time allowance, it is recorded on a job ticket ; as the workman reduces this time allowance, his rate of wages per hour, while he is working at the job, *is increased by the same percentage as that by which the time allowance has been reduced.* It is apparent that data must be collected for the purpose of arriving at the time which should be allowed to do work. For this purpose a special department (rate-fixing department) is required, and when instituted, data accumulates very quickly. The period occupied in doing work under the usual time payment conditions may be accepted as the time allowance of the premium system.

THE SYSTEM AT WORK.

A job ticket is issued when a job is given to a workman, with a description of the work to be done, and the time allowed for it. On completion of the work the job ticket is initialled, and the hour recorded on it by the foreman, and this marks the time of commencing the next job. When the work has been examined and passed by the works inspector, the job ticket is handed to the rate-fixing department, which passes the same for payment. In the case of a job being rejected by the inspector, any premium which would otherwise have been earned by the workman, by reason of his having reduced the time allowance, is forfeited. No clerical labour devolves upon the workmen and very little upon the foremen.

The time allowance for a job given to a workman rated at, say, 8d. per hour is 100 hours and the actual time occupied on the job amounts to say 75 hours. We have then 100 hours at 8d. = 800 pence, against 75 hours at 8d. + 25 per cent. (2d.) = 750 pence, giving the workman a premium = 150 pence, or 2d. per hour, and the employer a reduced cost = 50 pence. Provided the time allowances are equitable to employer and employed, and based on the average attainments of hourly labour, it will be evident that the higher the premium earned by the workman the greater will be the saving in cost. The output of the machines is also increased, but it is a hard matter to put a value to this. Occasionally a piece of work is begun on one machine and finished on another. In a case of this kind the job ticket is passed by the first to the second operator, and so on until the work is completed, each workman engaged upon it receiving any premium earned in proportion to the total reduction of time made in completing the whole job. Any number of men may be employed on the same piece of work, and it is not necessary that they should all remain at the work for the same period, because a slump time allowance is made to cover the time of all the men on a job, and the total time spent upon the job fixes the premium percentage, which is used in fixing the premiums of the different men only to the extent of the time each has been employed upon the work. Thus, a job for which the time allowance is 1,000 hours may be performed in 800 hours—one man might work 100, one 300, and one 400 hours. Each of these men would have his hourly rate increased to the extent of 20 per cent. for the time he had been employed upon the job.

The reduction or increase of a workman's hourly rate is not affected, as any change in either of these directions made during the time he is engaged upon a job is calculated at a percentage on his hourly rate or rates. Neither is any difficulty introduced in respect to overtime allowances, as the actual time worked upon a job determines the time upon which a premium is paid. The overtime allowance, which in the Glasgow district is paid at the rate of 50 per cent. on the overtime worked, does not appear in the job ticket as time, being only shown as such in the workmen's time and wages book as a unit to fix the value of the overtime allowances. In the job ticket this allowance appears at its value in money. Nor is there any difficulty presented when working a night shift, as each of the two men at a machine receives a share of premium earned in proportion to the number of hours worked on the job. Every man should work on his own account ; but there are cases, particularly in the erecting department, in which the inclusion of several men on one job ticket cannot very easily be avoided. Apprentices in their first year are not given a job ticket. In their second and third years they are junior apprentices, and half the time that they work is counted ; in the fourth and fifth years they are senior apprentices, and three-quarters of the time they work is counted. They are allowed the same time as a journeyman. In the machine department apprentices in the fourth and fifth year do the same kind of work as is done by journeymen, and they are allowed 25 per cent. more than journeymen.

The premiums are not paid until 5 per cent. has been earned, and afterwards only in multiples of 5 per cent. The original time fixed upon as a time allowance is never reduced, unless there has been a radical change in the method of doing a piece of work. As a rule, the premiums earned by the men have increased since the introduction of this system, sometimes owing to the industry, skill, or intelligence exerted by the workman, but oftener due to those who exercise a controlling power. The value of this premium system is not limited to a saving in cost of labour by the reduction of the time taken to do work. Numerous instances might be cited where the system has been the means of bringing to notice, through concentration of attention on its development, improved methods of manufacture.

THE REGISTRY OF PROGRESS.

Another feature to which special attention is directed by Mr. Rowan is the use of the job progress card. This card is prepared every morning by the rate-fixing department, and indicates the progress which has been made at the various machines. One column gives the machine numbers, another column the hours allowed for the jobs in hand, a third column gives the number of pieces included in each job, the fourth column shows the hours spent upon the job in hand till 10.30 a.m. on the date the card is prepared, and the fifth column contains the previous records for similar jobs. The card is, therefore, an index of the progress of work in each and all the machines in operation.

There is a job register book for the machine, brass-finishing, tinsmiths', and smiths' departments, erecting in the works, and fitting the machinery in the yard and at the quay. As new jobs occur they are duly registered. Each separate job in the manufacture of a marine engine, from the time the castings and forgings come into the works until the ship leaves after her trial trip, is registered in this book.

In a job data book is a record of the work done on each article, and this book now contains a most complete and miscellaneous collection of data in connection with the manufacture of marine engines, and of other work. All whitewashing and painting, shifting of machines, laying down concrete floors, shifting of material from place to place, and many other operations for which, formerly, it would have been impossible to fix a time, are now recorded in the job data book.

THE ADVANTAGES OF THE SYSTEM.

This system is a step towards the solution of piecework. The value of tools is emphasised, the use of aids is found to be necessary, and inefficient machines are discovered. Managers and foremen meet more freely for the discussion of questions arising in the course of manufacture, better wages are earned by the men, and more work and better work is got out of the machines and the whole plant.

From this system Mr. Rowan claims that three advantages follow. No matter how long a man takes to do the work, whether from novelty, misfortune, misadventure, dawdling over his work, or carelessness, he receives his hourly rate of wages. If a man is repeating the same job on the same machine, and continually reducing the time of production, he is encouraged, as by all means he should be, to continue doing so. If the time allowance has been fairly fixed at the beginning, the more a man earns the cheaper is the work. In other words, the element of participation is introduced.

THREE SYSTEMS COMPARED.

Mr. Halsey's plan is to pay a certain fixed sum per hour saved—the premium varying with the men and the operation, but never starting high. As a basis he suggests assuming that the output of a shop can be doubled, and then considering how much the shop can afford to raise payment to secure such an increase. It is not to be expected that such an increase can actually be made, but the assumption gives a concrete form to the question to be dealt with.

Mr. Rowan's plan is to pay a premium bearing the same percentage to the fixed rate as the time saved by the workman bears to the time fixed by experience to the job. Thus a time is given to the workman in which the job should be done, and he is paid a fixed hourly rate. This hourly rate is increased by the same percentage in which he reduces the time over the job. If he saves 10, 25, or 50 per cent. of the time given, he receives 10, 25, or 50 per cent. more wages. If he saves, say, one-third of the time a man working at an hourly rate of 9d., he will receive 1s. an hour, and so on.

Under the plan adopted by Messrs. G. and J. Weir, Glasgow, the workman is paid a premium equal to one half of the time saved. Now, if we take the case of a job on which the workman is paid 8d. an hour, and 100 hours are allowed, the premium would work out as follows under the three systems, should the job be done in half the time, say 50 hours :—

	Time wages. s.	Premium earned. s.	Total cost. s.	Rate per hour. d.
Halsey (⅓ of saving)	33·3	11·11	44·4	10·66
Weir (½ of saving)	33·3	16·6	50·0	12·0
Rowan	33·3	16·6	50·0	12·0

But if the work were done with a saving not of 50 but of 20 hours, the comparison would be thus :—

	Time wages. s.	Premium earned. s.	Total cost. s.	Rate per hour. d.
Halsey	53·3	4·44	57·7	8·66
Weir	53·3	6·66	60·0	9·0
Rowan	53·3	10·66	64·0	9·6

With regard to the reduction of time, it is claimed that the credit of it is actually due more to the employers than to the men, because the possibilities of the tools under the premium plan have caused the masters to devote more attention than ever to the condition of the plant.

THE FEDERATION AND THE PLAN.

The following is an abstract from the letter forwarded by the officials to the members of the Engineering Employers' Federation:—

The question of the introduction of the bonus or premium system into the workshops of certain federated firms, and the difficulties which had arisen in connection therewith, came up for discussion at a central conference held at Carlisle on the 19th and 20th August, with the Amalgamated Society of Engineers and the Steam Engine Makers' Society.

The question had previously been discussed in local conference, but no settlement reached. The outcome of the discussion in central conference was a general understanding by which any federated firm is free to adopt this system of remunerating their workmen.

A signed memorandum, which was exchanged between parties, and of which a copy is appended.

MEMORANDUM.

The employers' representatives have not the power to settle the conditions which should be observed in connection with the working of a Bonus System, without having previously obtained authority from the Federation, in proper form.

They are prepared, however, to advise all employers who wish to establish such a system, in the meantime, to adopt the following suggestions :—

1. The time rate of wages (for each job) should in all cases be paid.
2. Overtime and nightshift to be paid on the same conditions as already prevail in each workshop.
3. A time limit after it has been established should only be changed if the method or means of manufacture are changed.
4. No firm should establish the Bonus System without intending to adhere to it.

THE PREMIUM SYSTEM IN AMERICA.

In America, as in Great Britain, it appears that in every case where the plan has yet been introduced, the employees have received it with some feeling of suspicion, but in the shops where the plan has passed the trial stage, it is uniformly popular with the men.

As an American employer who has tried it, Mr. H. M. Norris, says, it is obvious that increased earnings can be made only through the reduction of costs. "This, the premium plan secures, bringing it within the pale of the strictest principles of economics. Were it otherwise, it could never have stood the test of the sixteen years that have elapsed since the date of its inception. Under this system the workman is given an opportunity to profit by his industry. He is raised from a mere automaton to a man, alive to the possibilities of bettering his condition—an intelligent worker, certain of receiving a just share of his employer's profit. Is it not clear that here is the path to the goal that both parties have striven so long to reach—high wages and low cost?"

WORKSHOP PRACTICE

A RÉSUMÉ OF MACHINE TOOLS, CRANES, AND FOUNDRY MATTERS FOR THE MONTH.

MACHINE TOOLS.

THE series of articles on "Milling Machines," concluded in the present issue, has dealt with a subject, the importance of which in the modern shop it is impossible to rate too highly. They illustrate in a striking degree the battle of rotary cutters versus single-edged reciprocating tools, a struggle the first note of which was sounded when Vaucanson made a rotary cutter in France more than a century ago.

To those whose fancy runs in philosophic channels, the milling machine is but an incident in a wider system, in which other units have their influences. The writer remembers milling cutters in the shops twenty-five years ago, in which the temper was drawn, and the cutter rehardened as often, as the teeth required to be reduced considerably in consequence of wear. For something like three-quarters of a century the milling cutter remained little more than an occasional help in the shop, a kind of amateur's tool, brought into requisition when some one with more foresight and patience than his ellows divined its potentialities. And so it would have remained to-day, but for the fact that two or three firms, in advance of the times, foresaw the utilities of the emery wheel in tool grinding, and showed that it might be used for this, preferably to the grit stone. It is not long since the last echoes of the controversy respecting grindstones and emery wheels died away. In too many conservative shops the older practice still survives. With the many improvements in the manufacture of various grades of emery wheels, and the use of water, the real era of the milling cutter commenced. The design of different kinds of machines to grind the various forms of cutters demanded rapidly developed, and they are still being modified and improved from time to time.

And when the milling cutter gained an established position in the workshop, the sphere of its utility became widened by reason of its value in cutting gears. It is this, even more than the advantages which cut gears possess over cast ones, that has tended to the further disuse of the latter. Without the milling cutters, the cast gears would still retain their old pre-eminence. For some years most wheels of small dimensions, spur and bevel, were—as they still often are—cut on milling machines of the pillar and knee type, using the dividing head and change wheels. Gear cutting machines built after this general model followed, after which more highly specialised gear cutters have been designed.

The milling cutter has also been the parent of other developments. Few general shops number a relieving lathe among their equipment. But this type of tool is indispensable where cutters are manufactured, for producing the backing off, or clearance, on each tooth. In the old days this was laboriously filed. Then a to and fro motion at regular intervals was adapted to the cross slide of an ordinary lathe to give short cuts to each tooth. Now lathes are built to fulfil these functions only.

One of the greatest events in the history of the milling cutter was the invention of the Brown and Sharpe device, known as the form cutter, in consequence of which the sectional shape of the teeth is retained unimpaired after hundreds of successive grindings. It simply consists in striking the backing off curves at a different centre from that of the centre of the cutter. Its immense value is seen in the cutters for wheel teeth, and similar curved types. Once a cutter is formed and hardened, its teeth remain of exactly the same section, until ground away too thin to be strong enough for further cutting service.

Milling cutters also occur in forms once utterly undreamed of. With improved methods of hardening and grinding, cutters very long and large on the one hand, or of irregular profiles on the other, do not present such great difficulties as they once did. One of the principal reasons for the success of large and broad surfacing edge cutters is the spiral direction given to the teeth. This would not have been practicable without the grinding machines, fitted with swivel heads and change wheels. Another is the growing employment of inserted cutters, which are fitted to edge and face mills. These, and the solid mills with staggered teeth, render the milling machine capable of removing coarse chips over large areas with resultant great economies over the planers. The inserted cutters are many years old, within the writer's knowledge, but their utilisation in the rotary planing machines is a comparatively recent growth.

Electricity is going to exercise another influence in the development of milling practice —that of rendering these machines portable. By means of the electric current many machine tools are now taken to the work and set down in a convenient position for operation. Drills, shapers, and key seaters are cases in point. Little has been done as yet in this direction in milling machines, but developments along this line will certainly be witnessed within the next few years.

FOUNDRY MATTERS.

Among recent foundry developments, that of the rapidly increasing use of moulding machines must take a foremost place. Everywhere firms are found laying down these machines, often to the surprise of moulders, who are unacquainted with their capabilities.

The difficulty which always presents itself when selecting machines is that of adaptability to the shop conditions. There are many dozens of types built, and each in several sizes. It is rather a matter for surprise where all these machines go to, in view of the many shops into which they have not yet penetrated. But in some foundries machines are laid down by the dozen, or the score, and where they are once installed they generally form a nucleus for future growth.

The place *par excellence* for moulding machines is in those foundries where work is standardised. Formerly it would have been correct to say where work of small dimensions is standardised, but that restriction no longer holds good, for castings of several feet in length or diameter are now made either by hand, or power, as readily as those which measure a few inches only.

The mistake which is apt to be made is to suppose that a type of machine which is suitable for one class of work is also generally adaptable to all kinds of work. It is as erroneous an idea as to imagine that a machine tool of one kind is universally adaptable. There is now nearly as much differentiation between moulding machines as between machine tools. They vary in methods of moulding, in ramming, in rapping, in withdrawal, and in subsidiary features of their designs, as well as in motive power. Shallow and deep patterns are generally moulded better on different classes of machines, and light patterns and heavy also. In some cases stripping plates are indispensable, in others they would entail an unnecessary expenditure. Mechanical ramming is suitable for some work, destructive to others ; so is mechanical rapping.

Again, there is the important question of power. Hand operated machines fill a useful place in the shops ; but as power installations become more common in foundries, the hand machines, excepting for very light work, are bound to go. Much, of course, is done by arrangements of levers and counterweighting to render the operation of very large hand machines possible. But there is an economical limit to this.

Rival agencies are steam, water, and air, all of which are used freely. The choice of either depends generally on the plant which happens to be laid down. American makers favour steam and air, Germans chiefly employ water. Some of the latter machines are of enormous dimensions, and include tracks on which two boxes are used, being run along in turn under the presser.

In shops where machine moulding becomes established on a large scale everything is made subservient thereto. In some cases rows of machines are fixed; and boxes, sand, and moulds are brought to and taken away on tracks. In others the portable system is adopted, and the machines are wheeled to the sand, and the boxes, and away from the finished moulds. In such systems the labour costs compared with hand work come out in very fractional proportions, and skilled labour becomes nearly superseded. Machine moulding is changing the aspects of many foundries, and is destined to effect greater changes in the immediate future.

CRANES.

Crane accidents are much too frequent, and they sometimes seem to take an epidemic form. Many occur of which the public never hear because they occur in shops. Only when they terminate fatally, or when a serious accident occurs that must be reported to the district inspector of factories, or when they occur on public works, do they become matters of general knowledge.

Accidents happen in course of erection, during testing, and in actual service. There are also many narrow escapes. To say these are all preventable would be going too far, but many of them are due to bad design, carelessness in erecting, or inefficient operation.

The fracture of bed castings is a frequent cause of accidents. This chiefly occurs in new designs. It is not easy to apportion the sections of beds to correspond with the strains without much practical experience. The reason is that stresses due to unequal cooling lessen the calculated strengths, in designs which are not the outcome of previous practical experience.

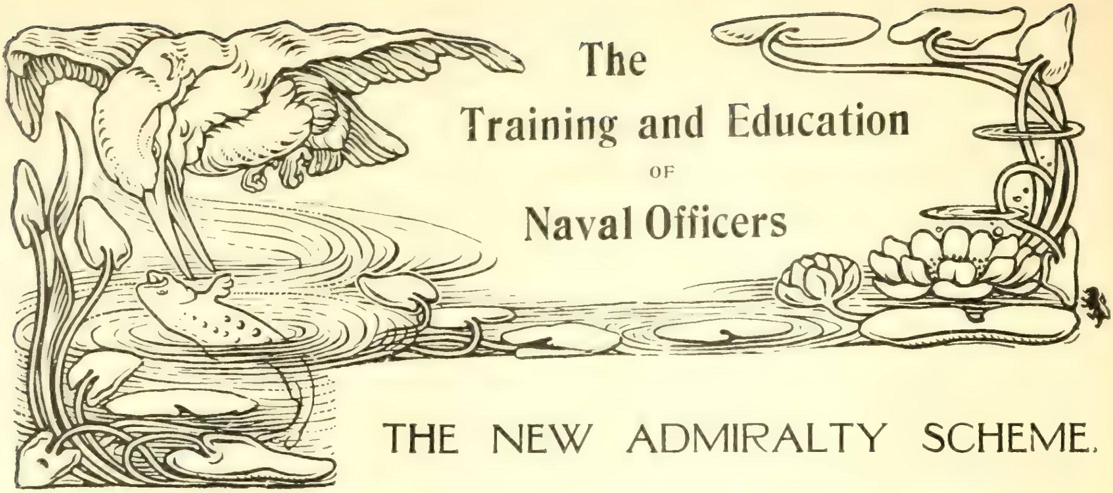
Other castings which have broken are chiefly side cheeks or frames, due to the pull of the tension rods of the jib. This occurs chiefly in consequence of a heavy surging of the load, in which event the load in front, and the balance behind, pulling against each other, severely strain the side frames. Sometimes the tension rods or chains have failed instead of the frames, in consequence of these strains. In minor cases the jib has been bent sideways. Accidents of these kinds are mostly due to sudden and severe shocks, rather than to steady stresses.

Chains become a dangerous element in cranes, unless they are frequently overhauled and tested, by inspection, and by tapping them link by link with a hammer. Chains, originally sound, develop crystallisation and minute cracks unless they are annealed at intervals of six or twelve months, by heating them to a red heat, and allowing them to cool down slowly.

A rather frequent accident is that due to the running down of the jib in derrick cranes. This is owing to neglecting to put in the clutch. There are safety devices patented, but they are not much used.

Sometimes a crane surges backward and falls over when heavily counterbalanced, due to the too sudden release of the load. Overhead travelling cranes are especially liable to break down unless well designed. Several instances have occurred of travellers running off the rails and tumbling into the shop or yard below. This may be the result of too short a wheel base, or to too loose fitting of the flanges of the wheels to the rails. It is, of course, sometimes due to overloading.

Risks of accident can never be entirely eliminated, because of the frequency of new designs, and divergence in types becomes constantly more and more marked. As long as crane firms work on old well-proved designs, they are safe enough; for good cranes, like perfect machines of other kinds are evolved, and not designed perfectly, *ab initio*. There are always, therefore, some elements of uncertainty and risk in novelties, and therefore accidents will sometimes occur in spite of every precaution.



The Training and Education of Naval Officers

THE NEW ADMIRALTY SCHEME.

1. Notes by a Naval Officer. 2. The Scheme Criticised by a Naval Engineer.

1. NOTES BY A NAVAL OFFICER.

REFERENCE was recently made in this magazine to an expected Admiralty scheme of reform in naval education and training. The scheme is now known, and it must be considered in the first place a veritable triumph for science, and primarily, for the science of engineering in all its branches. The scheme is a recognition to the fullest extent, not only of the fact that the mechanical engineer has superseded the practical sailor as the supervisor of the motive power of the ship, but that the person who directs the motion of the ship and uses that ship's armament must have a higher scientific training than is given him to-day. I should be the last to dispute that many of the flag officers, captains, and commanders, who direct and control the movements of our squadrons and ships are not engineers in the highest sense of the word, but it must be acknowledged that they have become so in spite of many difficulties, and not because of official assistance. It is unnecessary to search for examples of naval engineers, in the sense in which I have used the term, in the service itself, we have only to look at those men who have come out of the service and taken civil employ with the great engineering firms of Armstrong, Whitworth and Co., Vickers, Sons, and Maxim, and Whitehead, the torpedo builder, to understand how even on the naval training of the present day may be grafted qualifications which are in the highest degree scientific. It has been said, and perhaps with a certain foundation, that there are no marine engineers on the Board of Admiralty; but this is no longer true, if we substitute for the term marine engineer that of engineer without the qualifying adjective. The majority of admirals on the Board are scientific men, men who are engineers by reason of their high attainments in connection with the sciences of gunnery, electricity, and applied mechanics. The Admiralty scheme, as I understand it, will add to the other qualifications of our naval officers a full knowledge of the science of marine engineering.

Putting on one side what we may properly term the civil branches of the Navy, those connected with medicine, the Church, and the accountant duties, there are three classes of officers, the scope of whose work lies with the movement, direction, and combatant powers of a man-of-war. The officers of these three classes are now supplied by three different methods; the executive officers to whom are entrusted the direction, control and fighting powers of the ship, are entered young, by nomination, and pass through a training ship, the *Britannia;* the engineer officers, who provide the motive power of the ship, enter somewhat older and by various channels, and undergo quite a different training;

the marine officers, whose functions are entirely different again, enter in another manner, and these classes in their upward progress to the superior grades remain totally distinct from one another. The new scheme brings all three together at the point of entry, makes no difference in their early training, no distinction in their titular nomenclature, or uniform, and opens to every officer the possibility, if no more, of rising to the highest posts which the Navy offers. It provides, indeed, that the naval officer of the future shall, by his training, combine in himself the possibilities of performing the functions of all or any of those pertaining to the three classes as they are at present. As Lord Selborne says in the memorandum: "The policy of the Board is to create a body of young officers who at the moment of mobilisation for war will be equally available for all the general duties of the fleet, and to consolidate into one harmonious whole the fighting officers of the Navy."

To give this training it is necessary that the officer should be entered when he is but a boy, and, in order to remove all traces of social difference, by nomination. All the educational authorities are agreed that to put a boy before he has attained the age of fourteen through a stiff competitive examination would be an error. The competition therefore will be limited by limiting the number of entries—in other words, by restricting nomination. But, having passed his preliminary examination, the boy's practical education at once begins. Alongside his mental culture he will receive a training in the shop at the lathe and with the tools of the mechanical handicraftsman. After from three to four years of this training he will go to sea as a midshipman to acquire the capacity for command, for assuming responsibility, for exercising self control, and to gain that intimate knowledge of his profession which can only be obtained by placing him when young in charge of men. He then returns to college to undergo a further training both theoretical and practical. Hitherto, all the young officers have been trained together, but now, after the last period of training, there will be an opportunity for the sub-lieutenant to differentiate and to choose for himself the line in which he desires to make further progress. Three lines will be open to him, those of marine engineering, executive or deck work, and that of the marine. Having made his choice, he has again to undergo a course of training specialised according to the line he has selected. The lieutenant E. will be given every opportunity to make himself acquainted with that particular branch of science he affects, and similarly the lieutenant G. and the lieutenant M. Nor do the examinations end here, for lieutenants will have to pass for the rank of commander. Thus every officer will be qualified to keep a watch on deck or in the engine room, to command a gun's crew or handle a company of infantry, to navigate the ship, and to repair the machinery if mishaps occur. It does not follow, of course, that an officer will have to take spanner or cold chisel in hand, but, just as the sailor officer knew how to pass a weather reef earring in a gale of wind or send down an upper yard, so will the scientific officer of the future know how to meet emergencies with his electrical and other engines, though he may not actually have to put his hand to them.

It is unnecessary here to refer in detail to the other changes brought about by this great scheme, which some may call revolutionary, but which seems to me to be merely the natural development brought about by the scientific progress of the age.

Not all of these changes have been received with general approbation; criticism there must be, and, very naturally, some of the older officers have been horrified by ideas which appear to them so novel and so startling. But, on the whole, I believe that the more closely the scheme is considered the more sound-minded men will applaud it, will be grateful for the courage which has inspired it, and for the marvellous administrative grasp which is shown in every detail.

LORD SELBORNE'S MEMORANDUM.

Lord Selborne's memorandum dealing with the entry, training, and employment of officers and men of the Royal Navy and the Royal Marines was published on Christmas Day, and is introduced by a statement of the reasons which rendered reorganisation in these matters necessary. In these introductory remarks he says :—

The Navy has reached a critical period in its development—a development which, steady and comparatively slow for the greater part of the last century, has now for fifteen years proceeded with startling rapidity.

After the great war, from 1815 onwards, there ensued a period of readjustment and retrenchment ; the half-pay list embraced the majority of the officers of the Navy ; comparatively few ships were in commission ; it was necessarily not a period of innovation or of new ideas.

The application of steam to ships of war as a source of motive power was the first sign that the old order was beginning to change. At first admitted grudgingly as an occasional auxiliary to the sails, then acknowledged as an equal partner, then winning for itself supremacy, to-day the steam-engine has no rival, and sails have for ever disappeared from the equipment of fighting ships.

Gradual as was the revolution in respect of steam, so were the changes gradual in respect of the type of ship, her armour, and her guns. The wooden *Victory*, with her sail power and her 100 guns, eventually became transformed into the iron *Inflexible*, with her oval-tank boilers and her four 80-ton guns, but the process had been a slow one. The Navy had then been brought to the verge of a period in which vast improvements were about to take place in the battleship herself and in all the *matériel* which she contained. Cylindrical or locomotive boilers at low pressures were to give place to water-tube boilers at 300-lb. pressure ; the strength and power of the engines was to receive marvellous development ; numberless auxiliary engines were to replace manual labour or to fulfil functions unknown before among naval requirements ; muzzle-loading were to give place to breech-loading, and they in their turn to quick-firing guns ; brown powders, with much smoke and low velocities, were to be replaced by smokeless powders giving an ever-increasing velocity ; the storm of shot and shell capable of being poured into or from a ship was to become ever more rapid and ever more murderous ; to meet these conditions the whole fabric of the ship was to change, and Krupp or Harveyised steel to be substituted for compound armour, as compound armour had in its turn been substituted for iron ; and, finally, the ship herself, whose form and lines had during the transition period been the subject of wild experiment, was to regain a settled type in the *Majestic* class.

By a strange decree of fate the climax of this revolution in the *matériel* of the Navy has synchronised with its recent extraordinary development of strength in ships and of strength in men.

It is difficult to measure the change which has taken place in the last fifteen years. In that short period the officers and men of the Navy and marines have increased from about 60,000 to over 120,000. There are several foreign navies more powerful to-day than the British Navy was fifteen years ago, and yet the relative standard has been maintained. Of the ships which formed the effective ships of the Navy fifteen years ago but few remain on the effective list now.

The country can judge for itself what years of strenuous labour these have been for the Admiralty, years in which every task fulfilled was forgotten in the anxious effort to fulfil tasks which had yet to be done.

Throughout this period the Board never lost sight of the most important question of all those which confronted them, the education and training of the officers and men of the Navy, and the adaptation of that education and training to the new conditions under which the Navy has to work. Last year it was decided that the time had come formally to announce that training in masts and yards had disappeared never to return, and the growing importance of a fuller knowledge of engineering was emphasised by the order that in the future gunnery and torpedo lieutenants were to be held responsible for the care of the mountings and machinery of the weapons over which they have charge.

In the old days it sufficed if a naval officer were a seaman. Now he must be a seaman, a gunner, a soldier, an engineer, and a man of science as well. It is not only that machinery driven by electric, hydraulic, or steam power is every year becoming more complicated in character and multiplying in form, and that therefore a more extensive education in applied science is necessary for specialised officers, but in various ways the need for a more general scientific training has become apparent. In dealing with this question the Board have been always conscience of the supreme importance of preserving to the naval officer his unmistakable naval character.

This character is developed from the early training in responsibility, the powers of self-reliance thereby engendered, and the essential unity of the service. Notwithstanding the fact that during the transition period the system of naval education has been the subject of much criticism, the character of the naval officer has remained unimpaired, and character is of more value than knowledge. Now, however, as always, the highest type of naval officer is that wherein great professional knowledge is added to force of character. The danger within the Navy itself is lest insufficient importance should be attached to the results of study and lest the value of what is called the practical character should be placed higher than it deserves. It is true that no student will ever become a victorious leader unless he is also a practical seaman and has the power of influencing men ; but it is also true that no seaman, however practical, will be fit to rise beyond a certain rank unless he has thought out the problems of his calling as a student, and has omitted no opportunity of acquiring the knowledge that makes up the science of his profession. The officers of the Navy have never had cast on them a greater responsibility than at present, or one more difficult to fulfil. Their task will be impossible unless the Navy is kept abreast of the scientific, intellectual, and physical progress of the age, and it is they themselves who must keep it there.

The strength which its unity gives to the service can hardly be over-estimated, yet in respect of this very matter a strangely anomalous condition of affairs exists. The executive, the engineer, and the marine officers are all necessary for the efficiency of the fleet ; they all have to serve side by side throughout their career ; their unity of sentiment is essential to the welfare of the Navy ;

yet they all enter the service under different regulations, and they have nothing in common in their early training. The result is that the executive officer, unless he is a gunnery or torpedo specialist, has been taught but a limited amount of engineering, although the ship on which he serves is one huge-box of engines ; that the engineering officer has never had any training in executive duties ; that, from lack of early sea training, the marine officer is compelled sorely against his will to remain comparatively idle on board ship when everyone else is full of work ; and that the spirit of unity has not yet been carried to its full development.

The Board of Admiralty have studied this question of the education and training of naval and marine officers with prolonged and assiduous care, and they have determined on changes which they are convinced are adapted to the changed conditions of the time and will increase the efficiency and solidarity of the service.

These changes are far-reaching, and in some respects sweeping, but the scheme which necessitates them is framed in pursuance of a definite policy, is planned on clear lines, is designed to deal with the problem as a whole, and is throughout conceived in a spirit of veneration for all that is best and highest in the traditions of the service.

THE NEW SCHEME.

By the new scheme all officers for the executive and engineer branches of the Navy and for the Royal Marines will enter the service as naval cadets under exactly the same conditions between the ages of twelve and thirteen. These cadets shall all be trained on exactly the same system until they shall have passed for the rank of sub-lieutenant, between the ages of nineteen and twenty. They will then be distributed between the three branches of the service which are essential to the fighting efficiency of the fleet. The result aimed at is, to a certain point, community of knowledge, and life-long community of sentiment. These opportunities will be secured by a policy of one system of supply, one system of entry, and one system of training.

ENTRY AND TRAINING UP TO THE AGE OF ABOUT TWENTY.

In his outline of the scheme, Lord Selborne states that every detail connected with the education of these young officers will be carefully thought out and considered, and the best authorities, naval and civil, will be consulted by the Board of Admiralty.

He next explains why it has been decided to revert to the early age of twelve or thirteen for entry. This is considered necessary if the cadets are to receive that increased professional education which is required to qualify them to become commissioned officers. The age not only corresponds to that at which the history of the Navy shows that boys have been most successfully moulded to sea character, but, also, it corresponds to the age at which boys leave private schools, and therefore to a natural period in the system of education which obtains in this country.

The entrance examination to the new Royal Naval College, which thus takes the place of a public school, will be of an elementary kind, and confined to those subjects in which a carefully educated boy has usually been instructed up to the age of thirteen.

For all cadets entered under these regulations payment will have to be made to the Admiralty at the rate of £75 per annum for the period under training, and there will be charges also for expenses incurred by the cadet, such as for washing, repairing boots and clothes, hair-cutting, pocket-money, etc. From the expiration of their period of training until they reach the rank of acting sub-lieutenant, their parents or guardians will be further required to make a private allowance of £50 per annum to each cadet. Additional information on this and other subjects connected with the expense of entering a boy will be found in the memorandum referred to.

While the cadets are under instruction at the Royal Naval College, and before going to sea, they will all receive similar instruction, which will comprise an extension of the present *Britannia* course, including elementary instruction in physics and marine engineering, with the use of tools and machines in connection therewith. At any time during their period of training, cadets who fail to attain a minimum standard or to show promise of sufficient development of intellect must be requested to withdraw. Lord Selborne goes on to state that :—

> At the end of this period the cadets will go to sea and become midshipmen (*Britannia* time counting, as at present). Special attention will then be paid to their instruction in mechanics and the other applied sciences and to marine engineering. The instruction of midshipmen in seamanship will be given as at present by an executive officer deputed by the captain ; otherwise it will, under the general responsibility of the captain, be supervised by the engineer, gunnery, marine, navigating, and torpedo lieutenants of their respective ships ;

they will be examined annually as to their progress in seamanship, navigation and pilotage, gunnery, torpedo work, and engineering, all set papers being as at present sent from the Admiralty; and at the end of three years every midshipman who has passed the qualifying standard at the last annual examination and the final examination in seamanship before a board of three captains or commanders (constituted as at present) will become an acting sub-lieutenant, and return to England. These acting sub-lieutenants will then go to the college at Greenwich for a three months' course of mathematics and navigation and pilotage, followed by an examination, and afterwards to Portsmouth for a six months' course in gunnery, torpedo, and engineering, at the close of which they will be examined, receive their classification, 1, 2, 3, in each subject, and on passing out be confirmed in the rank of sub-lieutenant.

Before the period arrives at which the first batch of cadets under the new system have to go to sea, the board will have considered very carefully and will have decided whether they shall be sent for the whole three years as midshipmen to battleships and cruisers ordinarily commissioned, or whether the first part of this period shall be passed in specially commissioned training-ships. It is quite decided that, at whatever period they are posted to ordinarily commissioned battleships and cruisers, compulsory school on board these ships shall cease.

When the young officers, aged nineteen to twenty, have passed out of the college at Portsmouth as sub-lieutenants, and have gained their classification in the different subjects of the examination, their careers for the first time will begin to diverge, and they will be posted to the executive or to the engineer branch of the Navy or to the Royal Marines. As far as possible each officer will be allowed to choose which branch he will join, but this must be subject to the proviso that all branches are satisfactorily filled. No sub-lieutenant will be compelled to join a branch for which he did not enter as a boy when applying for a nomination, but in giving nominations for competition for entrance to the *Britannia*, preference will (other things being equal) be given to those boys whose parents or guardians declare for them that they will be ready to enter either of the three branches of the service. The Board of Admiralty will thus have in reserve a means of remedying a surplus or deficiency in either of the three branches, and of insuring that every branch receives a due proportion of the most capable officers.

Up to this point the young officers' characters have been formed in one school, and all these sub-lieutenants have received, as the foundation of their professional education, that common knowledge which all alike require. Henceforward their education must be differentiated to make them fit to perform those specialised duties which are the product of modern science.

THE EXECUTIVE BRANCH.

The sub-lieutenants who join this branch will go to sea for two years, and after that will be promoted to the rank of lieutenant on gaining the same qualifying watch-keeping certificate as at present. Those who are selected to be trained as specialists in gunnery, torpedo, or navigation, will go to the Royal Naval College at Greenwich for special courses, and an entrance examination will be instituted at Greenwich for these specialists. Before promotion to commander a qualifying examination must be passed in the following subjects: Court-martial procedure, international law, knowledge of British and foreign warships, guns, torpedos, etc., naval history, signals, strategy, tactics, and battle formations. They will not, however, be able to offer themselves for this examination till they have attained five years' seniority in the rank of lieutentant.

THE ENGINEER BRANCH.

Sub-lieutenants of this branch (says Lord Selborne) will go to the College at Keyham for a professional course, the exact duration of which will be determined with great care. At the expiration of this course a proportion, to be equally carefully determined, will be selected to go to Greenwich for a further course, while the remainder go to sea. They will then, if found qualified, all be promoted to be lieutenants under the same conditions as the executives. The nature and duration of the special course at Greenwich will be very carefully determined, and an opportunity will be afforded to those officers selected for it to make themselves acquainted with the latest developments of engineering science, not only at Greenwich, but at the great civil engineering establishments and institutions which are to be found in the country.

By these arrangements sub-lieutenants of the engineer branch will obtain their step in rank at the same age as the sub-lieutenants of the executive branch, and they will enjoy the same opportunities of accelerated promotion according to the classifications they receive at their previous examinations. The ranks of engineer officers will be assimilated to the corresponding ranks of executive officers and the engineer officers will wear the same uniform and bear the same titles of rank—*e.g.*, sub-lieutenant (E), lieutenant (E), commander (E), captain (E), and rear-admiral (E). The engineer branch will receive additional pay, and although it is proposed to make the division into the various branches definite and final, every endeavour will be made to provide those who enter the engineer branch with opportunities equal to those of the executive branch, including the same opportunity of rising to flag rank.

The promotion of future lieutenants (E) and commanders (E) will, as in the case of the executive officers be by selection and qualifying service, and in the case of lieutenants (E) a qualifying examination for promotion to commander (E) will be instituted; moreover, the proportion of different ranks in the engineer branch will, as far as possible, be assimilated to that which will be fixed for the executive branch by the committee which is specially considering this question under the chairmanship of Lord Goschen. The endeavour will also be made to find a suitable number of high appointments for the flag officers of the engineer branch.

Amplifying and explaining the above statement that the division into the various branches will be definite and final, Lord Selborne has written to a correspondent, pointing out that this announcement can only apply to the principle by which the present Board must be guided in providing recruits for the three branches, and leaves a future Board perfectly free to relax the rule if it thinks fit; but it follows, of course, that unless a future Board does think fit, in the interests of the service, to relax the rule, the division will remain definite and final, and there will be no interchangeability. He says no useful purpose can be served by speculating on what a Board may do ten years hence or more; the essential thing is that they should be free to do whatever in their time is best for the service. This essential freedom of action will be secured by the present scheme.

THE ROYAL MARINES.

It is unnecessary to say more here on this subject than that, after his final examination as sub-lieutenant along with the future executive and engineer officers, the young Royal Marine officer will receive his special military training during the next two years, partly at the college at Greenwich and partly at the headquarters of the marine divisions. Specially good officers will be permitted to qualify as gunnery and torpedo lieutenants, provided they have kept watch at sea for one year. They will all be available for keeping watch at sea and for general executive duties; and on shore, when employed with landing parties in naval brigades, naval and marine officers will take command of one another according to their seniority in their respective ranks.

THE TRANSITION STAGE.

It is as well to quote Lord Selborne at length on this particular point, as it has already become the subject of some discussion and controversy. It will be seen that unless some modification occurs it may give rise to some curious anomalies, as, for example, there will be in charge of the engine-room department an officer in the old uniform and without executive training, and, under him, two classes of officers, one in the old uniform and without executive training, and the other wearing the executive "curl" and entered under the new system of training. It is obvious, however, that in a practical service like the Navy these distinctions cannot be allowed to continue, and that changes will come about making for their settlement and unification.

The cadet now takes about four and a half years to become an acting sub-lieutenant; under the new system he will become fitted for the general services of the fleet in seven years, while the engineer and Royal Marine officer will require about two years more for their special professional instruction. The new system will be introduced in Midsummer, 1903. To fill the lists during the interregnum between the old scheme and the new it will become necessary to have recourse to double entries for a period. After the entry of cadets from twelve to thirteen has commenced, the normal number of entries at fourteen and a half to fifteen and a half must continue to be made for two and a half years, so as to supply executive officers during the interregnum. The normal entries for the Royal Marine Light Infantry must continue for six years, and those for the Royal Marine Artillery must continue for five years at the present age; while the entry of engineer students at fourteen and a half to sixteen and a half must also continue for five years. The result of this will be that for two and a half years or rather more there must be two sets of cadets, those aged fourteen and a half to fifteen and a half, and those aged from twelve to thirteen; for many reasons it is considered unadvisable that these two sets of cadets should be trained together; it has, therefore, been decided to educate the younger ones in the Isle of Wight, where His Majesty has graciously put at their disposal a portion of the Osborne estate.

THE PRESENT ENGINEER OFFICER.

The Board are confident that the naval engineer officer of the future will maintain to the full the high traditions of the present engineer branch, but they feel that this scheme would not be complete if it did not include changes designed to harmonise, as far as possible, the position of the present officers of the engineer branch with the spirit of the future organisation.

Accordingly the following changes will be made in the designations of rank:—

Engineer students will become engineer cadets, and the College at Keyham will be known as the Royal Naval Engineering College.

Assistant engineers for temporary service and assistant engineers will become engineer sub-lieutenants.

Engineers, chief engineers, and staff engineers will become engineer lieutenants.

Fleet engineers will become engineer commanders.

Inspectors of machinery will become engineer captains, and

Chief inspectors of machinery will become engineer rear-admirals.

The engineer-in-chief will become an engineer rear-admiral, and the Board reserve power to promote the officer holding that high post to the rank of engineer vice-admiral if thought advisable.

The average period of reaching each rank will be assimilated as far as possible to that of the executive branch, so as to correct the present disparity of age which too often obtains between officers of the two branches of relatively equal rank;* the pay of existing engineer officers will be raised; but no changes will be made in their uniform or in the regulations which define their duties or in the provisions of the Naval Discipline Act.

The Board have given their careful and earnest consideration to all the suggestions which have been made from a variety of quarters for further changes affecting the present engineer officers. The decision at which they have arrived is, they are convinced, that most conducive to the interests of the service as a whole.

The following are the new scales of pay for the existing engineer officers and the future officers of the same department:—

EXISTING ENGINEER OFFICERS.

New Ranks and Scale of Pay.

Rank.	Pay per Diem. s.	d.
Engineer lieutenant	10	0
,, ,, After 2 years	11	0
,, ,, ,, 4 ,, ...	12	0
,, ,, ,, 6 ,, ...	13	0
,, ,, ,, 8 ,, ...	16	0
,, ,, ,, 10 ,,	17	0
,, ,, ,, 12 ,, ...	18	0
,, ,, ,, 14 ,,	20	0
Engineer commander	24	0
,, ,, After 2 years	27	0
,, ,, ,, 3 ,,	30	0
,, ,, ,, 4 ,, ...	33	0
Engineer captain	35-40	0
Engineer rear-admiral	60	0

FUTURE ENGINEER OFFICERS.

Rank	Pay per Diem. s.	d.
Lieutenant (E)	12	0
,, ,, of 4 years	14	0
,, ,, 8 ,, ...	16	0
,, ,, 10 ,, ...	17	0
,, ,, 12 ,, ...	18	0
,, ,, 14 ,, (maximum) ...	20	0
Commander (E)	24	0
,, ,, of 2 years	27	0
,, ,, 4 ,,	30	0
,, ,, 6 ,, .	33	0
Captain (E)	35-40	0
Rear-admiral (E)	60	0

The changes in pay in these tables and in those given below will take effect from April 1st of this year, and on the same date the engineers will assume their new titles. In neither case is the pay retrospective, and the titles are to be assumed by officers on the retired lists.

THE PRESENT MARINE OFFICER.

By the new scheme the present marine officer is to be made available for employment in gunnery and torpedo duties, and generally in taking a more active part in the duties of the ship. They will also become eligible for employment at the Admiralty. The following are the new scales of pay for those at present in the service and the future marine officers:—

EXISTING MARINE OFFICERS.

New Scale of Pay.

Rank.	Artillery Pay per Diem. s.	d.	Infantry Pay per Diem. s.	d.
Lieutenant	6	4	5	11
After 3 years .	7	5	7	0
Captain	12	1	11	7
After 1 year ...	12	7	12	1
,, 5 years	13	1	12	7
,, 8 ,, ...	14	7	14	1
Major	16	1	15	7
After 2 years .. .	17	0	17	0
,, 4 ,, . .	18	0	18	0
,, 6 ,, . .	18	6	18	6
Lieutenant-colonel ...	21	0	21	0
After 2 years ...	21	0	21	0
,, 4 ,, ...	22	6	22	6

Colonels 2nd commandant will receive pay of rank and an additional allowance of 5s. per diem.

Colonels commandant will receive pay at present rates, with an additional allowance of 12s. a day.

FUTURE MARINE OFFICERS.

Rank.	Pay per Diem. s.	d.
Lieutenant	10	0
After 4 years in rank	11	0
Captain	12	0
After 1 year in rank	13	0
,, 5 years ,, ...	15	0
Major	20	0
After 2 years in rank	22	0
,, 4 ,, ,, ...	24	0
,, 6 ,, ,, ...	26	0
Lieutenant-colonel	30	0
After 2 years in rank	33	0
,, 4 ,, ,, ...	36	0

Colonels 2nd commandant will receive pay of rank and an additional allowance of 5s. per diem.

Colonels commandant will receive pay at present rates, with an additional allowance of 12s. per diem.

WARRANT OFFICERS, PETTY OFFICERS, AND MEN.

After an introduction explaining why it has become necessary to make further changes in connection with the entry and training of the seamen and stokers, and their higher grades and ratings, Lord Selborne says :—

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* This pay of 16s. a day, together with the right to wear the uniform of the increased rank of engineer lieutenant of eight years' seniority, will be dependent on his obtaining a qualifying certificate and on being selected.

1. It is proposed to enter, between fourteen and sixteen years of age, boys to be called "boy artificers," who will be most carefully trained, and whose engagement will be to serve for twelve years continuously from the age of eighteen.

In this manner a second source of supply will be formed for the ever-increasing needs of the fleet in respect of engine-room artificers.

2. It has long been a complaint on the part of the engineer branch that an engineer officer on board each big ship is employed in clerical duties. It is proposed to remedy this by establishing a non-substantive rating of engineer's writer, and the engine-room complement will in future include this rating, to be held preferably by men of the stoker class.

3. The engine-room complement of every sea-going ship will also include the non-substantive rating of "yeoman of stores," to be held by a chief or leading stoker.

4. Young and promising leading stoker mechanics, not over thirty years of age, will be eligible for the new rating of "mechanician"; selected candidates will be required to pass the educational examination established for the rating of engine-room artificer; they will then receive a careful further training, at the end of which it will be sufficient if it is shown that the men possess the requisite skill to give valuable aid in the ordinary repairs and casualties of an engine-room or stokehold; "mechanicians" will take rank as chief petty officers, immediately after engine-room "artificers," and be granted suitable rates of pay, increasing with length of service.

The stokers have been recently placed on an equality with the seamen and marines in respect of the grant of a free kit on entry. This concession and the addition of these three new ratings will, it is hoped, greatly augment the attractiveness of this service.

5. The numbers of artificer engineers and chief artificer engineers will gradually be largely increased.

6. There has been for some time past a deficiency in the signal ratings of the fleet. To remedy this an increase has been made in the pay of the class by the grant of 6d. a day to a large percentage of the higher ratings, and thus the signal ratings have been put upon an equality with the gunnery and torpedo ratings, and the expected result of attracting the required number of volunteers for the signal branch of the service has been produced.

7. There has for some time past been a strong feeling that the appearance, the system of training, and the standard of efficiency of naval bandsmen are unsatisfactory, and that an unfair proportion of the cost of naval bands falls upon the officers.

The Board have now under consideration a plan for the complete re-organisation of naval bands, the effect of which it is believed will be to bring substantial relief to the officers in the matter of expense.

8. The chief petty officers of the fleet have long felt it a hardship that, notwithstanding the great importance and responsibility of their position, they receive no higher rate of pension than a first-class petty officer.

The Board are glad to be able to announce that it has been decided to increase the pensions of chief petty officers by ½d. a day for each year's service in chief petty officer's rating subsequent to the completion of their first engagement. This apparently small change will alone entail an eventual charge on naval funds of no less a sum than £73,000 a year.

PROMOTION OF LIEUTENANTS FROM WARRANT RANK.

The Board have long been anxious to see their way to promote a certain proportion of gunners, boatswains, and carpenters to the commissioned ranks, and thus afford to the lower deck of the Navy opportunities of rising similar to those which the rank and file of the Army enjoy by the opportunity of promotion to the rank of quartermaster or riding-master. It is, accordingly, a great satisfaction to them to be able to announce that a list has already been drawn up of sixty appointments, to which these officers can be promoted, and that the proportion of each branch of warrant officer which will be promoted to lieutenant will be the same, as nearly as possible, as the proportion of each of those branches to the combined total of the warrant officers' list.

2. THE SCHEME FROM A NAVAL ENGINEER OFFICER'S POINT OF VIEW.

By CHAS. M. JOHNSON, R.N. (Chief Inspector of Machinery, Retired).

THE need for a drastic measure of reform in the matter of the *personnel* of the Navy has long been recognised by all thoughtful students of naval questions, and Lord Selborne, in the opening sentences of his memorandum, gives expression to the prevailing opinion in terms which are both courageous and statesmanlike.

In his remarks anent the application of steam to ships of war, which every engineer will endorse to their fullest value, we have at length the tardy acknowledgment by the Admiralty that engineering science is the predominant factor in naval economy; and I propose in the following pages to examine the provisions of Lord Selborne's new scheme in the light of this long-deferred confession. It will be convenient, for the more lucid consideration of the subject, to divide it into two parts, viz.: I. The Future *Personnel*, and II. The Existing *Personnel*.

I. THE FUTURE "PERSONNEL.

In dealing with the training necessary for the production of the "efficient" future naval officer, Lord Selborne says that the [illegible] marine officers all enter the service under different regulations, and they have nothing in common in their early training.

Here lies the real keynote of the "new scheme," which is to weld the various branches of the service in future into one homogeneous whole, each unit of which shall be available for assuming command, should the necessity arise. The object is an admirable one, though its practical attainment is a question as to which I have many misgivings. But I must do Lord Selborne the bare justice of admitting that if such homogenity can be secured, he has given us a very good foundation on which to raise the edifice. That the plans may need revision from time to time will be recognised by the warmest supporters of the "new scheme"; and Lord Selborne himself admits that much of its provisions are tentative, and liable to be modified as experience demonstrates the need.

The extracts from Lord Selborne's memorandum already given, will afford a very fair and adequate conception of the scope and nature of the changes which are to be wrought in the entry and training of the naval officers of the future. To the readers of this magazine, those points which bear on the future naval engineer will be of supreme interest, and I propose now to analyse Lord Selborne's provisions for their entry, training, and promotion, and endeavour to ascertain, as far as my experience and official knowledge permit, whether the engineer thus developed is likely to be the practical and theoretical expert we have a right to demand, shall have the care and management of the floating arks of complicated mechanism which constitute the warship of to-day, and which will tend every year to attain to a still higher degree of complicated refinement.

It is proposed that all naval cadets shall enter between the ages of twelve and thirteen, which is certainly erring on the right side, if it errs at all, because I do not think a youngster can too early be immersed in the atmosphere which is to surround his life's work. His mind should be accustomed, from the earliest convenient time, to think in the language and the formulæ of the profession he is to embrace.

The proposed mode of entry by nomination is a relic of Admiralty patronage, which the Board is unwilling to relinquish; but, whether the admirals like it or not, it must soon go the way of all such antiquated privileges. Open competition is sure to come within the next few years. The result of this entry by nomination will be to keep the naval service—as far as the officers are concerned—in the family circles of the Admiralty and their friends; so that parents without influence inside of that charmed circle will have no chance of getting their boys into the Navy, however desirable the boys themselves may be, or however ready the parents may be to incur the heavy expense of educating their boys for the service of their country.

Having been successful in entering the service as a cadet, the youngster has now to pass four years of study at the Royal Naval College. The curriculum, which will comprise an extension of the *Britannia* course, will also embrace elementary instruction in physics and marine engineering, with the use of tools and machines in connection therewith.

It seems to me that there is a very great weakness in this scheme of education. The lad enters between the ages of twelve and thirteen—for the purposes of investigation, let us assume twelve and a half as the lad's age on entry. On completion of the four years' education under this system he will be sixteen and a half years old. During those four years he has to acquire a thorough knowledge of all the subjects necessary to equip him through life as an educated man; and in between these numerous subjects there is to be sandwiched "elementary physics and marine engineering, with the use of tools and machines in connection therewith." So that at sixteen and a half years of age this phenomenal prodigy must have not only completed his general education (for all his studies after leaving the Royal Naval College will be limited to technical and professional subjects), but he must also have imbibed some rudimentary knowledge of physics and marine engineering, and of the use of tools and machines in connection therewith. Having seen some of the unhappy results of overcrowding the brains of boys and young men, I fear the "new scheme" means a large increase, in the near future, of the "derelicts" of high-pressure education. What amount of engineering knowledge and practice these lads will absorb in these short four years depends in a great measure on the kind of work provided, and still more upon their individual capabilities.

At the end of the four years—which may very aptly be termed "the educational period"—the cadets, now become midshipmen, will be sent to sea for three years. During this time, which may be termed "the sea-training period," they will be instructed in the duties of watch-keeping on deck and in the engine-room, seamanship, gunnery, torpedo work, navigation, and engineering, by the officers in charge of these departments respectively. There will be no continuation during this period of the general education of these young gentlemen, as it is fully intended to abolish the existing school system on board all ships which now carry a naval instructor.

Now, during this period of three years, the midshipman has to study five technical subjects; to learn to become an efficient watch-keeper on deck and below; and has also to pass three annual examinations in the five subjects and a final examination in seamanship before three captains or commanders (as at present). Preparation for the annual and the final examinations, will require four, out of the entire period of thirty-six, months; and another two months, at least, must be allowed for leave, recreation, sickness, etc., so that we are reduced to thirty months for the study of the five subjects; which gives us exactly six months for each. I think I shall not be straining a point if I ask what degree of efficiency is the midshipman likely to attain in either of the five subjects named in so constricted a period of time as six months. It must not be forgotten that, in addition to pursuing his studies, the midshipman has also to "keep watch." Well, we must suppose this midshipman to have passed all his final examinations on board ship successfully, and to have been promoted acting sub-lieutenant. He now returns to England, enters Greenwich College for a three months' course of mathematics, navigation, and pilotage, to be followed by an examination; then to Portsmouth for a six months' course in gunnery, torpedo, and engineering, to be followed by an examination, at which he will receive his classification of 1, 2, 3, in each subject, and on passing out will be confirmed in the rank of sub-lieutenant. Our imaginary sub-lieutenant is now nineteen and a half years of age, and—having elected to become an engineer—he passes to the College at Keyham to learn his profession, for a period, "the exact duration of which will be determined with great care." This sub-lieutenant's knowledge of engineering at this time can be but elementary and superficial in the extreme; and the shortest time in which he can hope to acquire thorough practical and theoretical acquaintance with the science of engineering can scarcely be reduced to less than four years, and may even extend to five. So that our sub-lieutenant, by the time he returns to the sea as a fully equipped sub-lieutenant (E), will be nearly, if not quite, twenty-four years of age, and all his contemporaries in the executive line will have been lieutenants from two or three years before. This, however, is a personal disability or grievance, and in no way affects his value to the nation as a qualified officer, although it tends to show one of the difficulties which the Admiralty will have to face in carrying out their promise that "every endeavour will be made to provide those who enter the engineer branch with opportunities equal to those of the executive branch." It is true that Lord Selborne estimates that this special course—which may be termed "the professional course," will only occupy about two years; but the readers of this magazine are better judges on that question than Lord Selborne, and I shall be surprised if they do not regard my estimate as being much nearer the mark than his.

At about twenty-four years of age, the sub-lieutenant (E) will be ready for active service afloat; and will thus have been about eleven years in training, from date of entry. He will still require a few months' training under more experienced sub-lieutenants or lieutenants (E) before he can safely be entrusted with the sole charge of a watch in a big ship, or a destroyer. For the succeeding five or six years he will have to serve in a subordinate capacity, until, having gained experience in all that relates to the management and control of naval machinery and the engineering department, he may, at thirty years of age, be considered fit to assume the charge of a torpedo-gunboat or a small cruiser. At the age of thirty-five or thirty-six he may attain the rank of commander (E), and be assumed to have sufficient experience to take charge of a second-class cruiser or a small battleship; progressing a few years later, say at forty-two years of age, to the charge of a first-class cruiser or battleship. Now, let me trace back a bit and see in how many years, from July, 1903—the date when the "New Scheme" is to come into operation—the first commander (E) will be ready to take charge of a line-of-battle ship. Our imaginary cadet, entering in July, 1903, at twelve and a half years of age, will, as we have seen, probably attain to this enviable position of trust and responsibility at the age of forty-two, or twenty-nine and a half years from date of entry. So that, in round numbers, we may say that the "New Scheme" requires for its full development nearly thirty years from the present year of grace. Even if we accept Lord Selborne's estimate of the time required for "professional training," it will be quite twenty-eight years before the "New Scheme" comes into complete operation. But if the "professional training" be limited to two years, as Lord Selborne suggests, what will be the value of the sub-lieutenant (E) as an engineer on joining his first ship as part-complement and as a fully qualified officer? Is it possible that he could be considered, with such an abbreviated training, a thoroughly well-equipped engineer?

II. THE EXISTING "PERSONNEL."

Put into plain English, Lord Selborne, in the portion of his memorandum relating to the present engineer officers, announces that the Board have come to the conclusion that a small increment of pay and an empty title are all the changes necessary "to harmonise as far as possible the position of the present officers of the engineering branch with the spirit of the future organisation." What is it that the engineer officers have been asking for during the past twenty years at least? They have asked that they might be given executive rank in order that they might have the authority pertaining to executive rank, to enable them the better to control their department and to maintain discipline therein. And "in order to harmonise, etc.," the Admiralty have bestowed upon the existing officers of the engineering branch a bastard executive rank, carrying with it neither the insignia nor the authority which have hitherto always accompanied, and have been and still are, the distinguishing characteristics of executive rank and titles. I hope the engineer officers of the Service will not be too bitterly disappointed; but I must admit that if the Admiralty Board had sat down deliberately intent on devising a scheme which should be, as it were, the proverbial "last straw," the ingenuity of man, combined with subtlety of the serpent, could not have hit upon a more certain plan.

There is, however, a certain humorous feature about the matter, which may, or may not, have occurred to their lordships when they concocted their latest, up-to-date, executive rank. As I have already shown in this paper, it will take at least thirty years for the "New Scheme" to come into full working order; but long before that time arrives there will be hundreds of sub-lieutenants (E) and lieutenants (E) afloat, doing duty in the ships of the fleet. The chief and senior engineer officers will still be those of the present race, those to whom the Admiralty are giving executive rank without insignia or executive power, and these officers will have to exercise authority and control over juniors possessing both the insignia and the executive authority—officers in fact, who, under certain circumstances, will be able to give orders to their senior officers, by virtue of the "pukkah" executive rank which they will possess. The grotesqueness of such peddling mal-administration overwhelms the "New Scheme" with ridicule.

LOCOMOTIVE ENGINEERING NOTES.

Mr. Holden's "Decapod."

In a previous issue of this Magazine reference was made to a wholly novel type of tank-engine for suburban traffic, which had been designed by Mr. James Holden, Chief Mechanical Engineer of the Great Eastern Railway, and was under construction at the Stratford works of that company. It will be remembered that its prominent feature consists in its being of the "Decapod" type, *i.e.*, having all its ten wheels coupled. Some exception has been taken to this designation, on the ground that the locomotive type to which, in America, the title "Decapod" is given, has its leading end carried on a two-wheeled bogie or pony-truck. As, however, the essential character of the decapod consists in tenfold coupling of its wheels, the addition or non-addition of a pony-truck is immaterial as affecting the type. Neither is it necessarily incumbent upon Britain to adopt American class designations in their integrity, especially when a term signifying ten-wheeledness is applied to a twelve-wheeled locomotive.

Mammoth Dimensions.

But apart from the tenfold coupling, which is believed to be an absolute novelty in British practice, the dimensions of the new Great Eastern engine have hitherto had no British parallel as regards magnitude. The new comer is, in truth, a veritable mammoth. It is noticeable, however, that, contrary to the too common British practice of employing gigantic cylinders and driving-wheels with a liliputian boiler, almost the entire vastness of Mr. Holden's new engine is concentrated in the boiler itself and its firebox. The engine, in fact, looks at the first glance to be "all boiler." Instead of having 8 ft. driving-wheels with a 4 ft. boiler barrel—dimensions not unknown in British practice—the new Great Easter has 4 ft. 6 in. driving-wheels and 5 ft. 3 in. boiler-barrel. The boiler, moreover, is no less than 15 ft. 6 in. long, while its axis is 8 ft. 9 in. above the level of the rails on which the locomotive runs. The firebox, which is of a novel type, is proportionately huge, and spreads sideways as far in each direction as it can possibly extend within the limits of the load gauge. Its length, however, is not remarkable, being only 6 ft. internally, but the grate area is enormous, being as much as 42 sq. ft. Steel boiler tubes, 395 in number and 1¾ in. in external diameter, provide a heating surface which, added to that of the firebox, amounts to a total of no less than 3,010 square feet, exceeding by more than 20 per cent. anything previously seen in this country, the nearest approximation being afforded by Mr. J. F. M'Intosh's eight-coupled Caledonian goods engines, "600" class, which have 2,500 square feet, and the Great Western ten-wheeled express, No. 100—now, by the way, named "William Dean," after the late locomotive superintendent—which has 2,400.

Some Additional Particulars.

A steam pressure of 200 lbs. to the square inch is provided, and no fewer than six safety valves will afford relief in case of need. Steam is admitted to the cylinders by a double-beating regulator, and here it may be mentioned that, although the engine is of the non-compound type, there are three cylinders, all, of course, are high-pressure, receiving "live" steam direct from the boiler. Each is 18½ in. in diameter, with a piston stroke of 24 in. The three cylinders are placed horizontally and side by side, two being external to the frames, and driving the middle pair of ten-coupled wheels, and the third inside, driving the second axle. This gives a tractive force of no less than 164 lb. for every lb. of effective steam pressure on the pistons, computed by the accepted formula of $\frac{d^2 \times l}{D}$, d representing the diameter of the cylinders, l, the length of the piston stroke, and, D, the diameter of the driving wheels, all in inches. As all the wheels are utilised for purposes of adhesion, and the total weight of the locomotive is sixty-seven tons, it will be seen that every ounce of tractive force yielded by the cylinders is taken up and employed in actual traction. Obviously, therefore, the new locomotive must possess stupendous haulage power. But it has other remarkable features yet to be noticed.

Some Novel Methods.

Perhaps the most important of them is in the character of the inside connecting rod. It has already been stated that the inside cylinder is exactly side by side with the two outside cylinders. All work in an absolutely horizontal line. It may naturally be wondered how the inside connecting rod clears the leading axle. This is very skilfully managed by means of a device which is applied by Mr. Holden in an entirely novel manner. It will probably prove epoch-making by enabling six-coupled express engines to be constructed with wheels of large diameter, and yet with inside cylinders, and without the necessity being involved of driving the leading pair of coupled wheels. To put the case briefly, the connecting rod passes *round* the intermediate axle. That is to say, it is made exceedingly broad, and has a circular aperture cut out through which passes the axle that has to be cleared. The rod—a very fine piece of steel work—is cut away in order to lighten it wherever this can be done without impairing its strength.

Some Minor Details.

Owing to the great height of the boiler, hardly any space is left above its top for chimney, dome or safety valve columns, and these accordingly are compressed to the smallest possible dimensions. The chimney, indeed, which suffers still further abbreviation through the slight elevation of the smoke box, is so short as to be barely perceptible at all, being only eight inches high; indeed, it is almost invisible to anybody standing beside the engine at the rail level, the effect being somewhat comic. Various new methods have been introduced of joining the coupling rods, of sanding the rails, and of arranging for the discharge of ashes from the smoke box. On these heads some fuller details may be given at a later date.

The Object Aimed at.

Many people may wonder *why* it became necessary to build such a mammoth locomotive for mere suburban service. The answer is, that this same suburban service has become the all-absorbing problem of the Great Eastern Railway. The traffic has outgrown all efforts to grapple with its demands. No fewer than fifty-two trains, each of fifteen six-wheeled coaches, have been built or converted to provide seats for twelve passengers in each compartment. The old coaches have been widened by the insertion of a vertical strip at each end, and a longitudinal one on each side of the floor, the roof being proportionately extended. But the steady increase of the traffic has already breasted these enlargements, and now the extreme limits of widening permitted by the load-gauge having been reached, as well as those longitudinally allowed by the stations, the sole recourse left has been to a numerical increase in the train service. [illegible] under existing method-conditions this was not feasible. As many sixteen-coach trains are run as can possibly be crowded on the lines with reasonably safety. By means of his clever little six-coupled tank engines, with 4 ft. wheels and 16 in. by 24 in. cylinders, Mr. Holden had enabled a speed of thirty miles an hour to be attained in sixty seconds from the dead start. The principal suburban trains have to start and stop no fewer than sixteen times in a total distance of 10½ miles.

The Device Adopted.

Only two alternatives presented themselves, One was to adopt electric traction, and transform the line at a cost of two millions sterling—a heavy " pull " on a railway which has never been recognised as a rich one. The other was to try some new device with steam haulage. The new locomotive, which is numbered " 20," is Mr. Holden's solution of the problem. He calculates that No. 20 will be able to start from absolute rest and attain a velocity of thirty miles an hour in thirty seconds, instead of requiring sixty to reach that rate of speed. If this estimate be realised in actual practice, then several more trains can be " sandwiched " into the existing crowded time table, and so it is hoped the present block and overcrowding and rush, which on one occasion swelled into an actual passenger riot, and led to the wrecking of a station, will be in a large measure at any rate, remedied, and the convenience of the travelling public greatly promoted. In any case Mr. Holden must be cordially complimented on the prescience and courage he has displayed in boldly stepping outside old traditions and experimenting with a novel design which, whatever its ultimate fate, must always mark an epoch in locomotive history.

Yet Another New Departure.

For some time past it has been an " open secret " that the Great Western Railway contemplated taking the step which has long been earnestly advocated by many progressive engineers outside official railway circles. It is pleasant to note that this step has been taken coincidently with the accession to office of the new chief at Swindon, Mr. J. G. Churchward. It consists in ordering an express engine of the world-renowned type designed by Mons. du Bousquet, Ingénieur en Chef du Matériel et de la Traction of the Chemin de Fer du Nord, on the four-cylinder compound system of Mons. A. G. de Glehn, Directeur Générale of the Société Alsacienne de Constructions Mécaniques, whence have come so many magnificent locomotives built on his system. That system has been undergoing steady development in France, Switzerland and Germany for several years past. It will be of the deepest interest to the whole British engineering world to observe the results of this important new departure of the Great Western authorities. But it is essential to its success that the " foreigner " should be ensured absolute fair play. That it will receive this from the Great Western locomotive authorities may be taken as beyond doubt. But the British driver is as a rule the most resolute of conservatives, and the most inveterate opponent of " new fangled " ideas. It is difficult to induce him to take kindly to a novel type of locomotive. Nothing is easier than for a good engine to get a bad name through unsatisfactory management. It may, however, be accepted as certain that Mr. Churchward will adopt measures for ensuring thoroughly fair treatment of the fine engine which has been ordered under his auspices, and which in its most important respect is the invention of an Englishman by birth. The splendid work done and doing by these engines in France is so widely known and indisputable, that if equally fine work were not forthcoming on that one being tried in Britain, the conclusion would be inevitable that the fault lay elsewhere than in the locomotive itself. But the Great Western has some exceptionally good drivers, and no doubt need be entertained that in their hands the de Glehn compound, at last to be tried in these islands, will receive full justice. C. R.-M.

PAGE'S MAGAZINE

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OUR MONTHLY RÉSUMÉ.

LONDON, 20th January, 1903.

Home Shipbuilding.

The shipbuilding returns for the year 1902 show a decrease of about 180,048 tons on those of 1901. This is not surprising, considering the complaints which have been so prevalent, and the depression that has been so evident in the later months. But it is a remarkable fact that the two greatest producing areas in the country—the Clyde and the Tyne—show actual increases, the former of 7,000 tons, and the latter of 10,000 tons. The total output of Scotland was 404 vessels of 567,886 tons and 533,128 i.h.p., as compared with 376 vessels of 554,400 tons and 472,190 i.h.p. Scotland has exceeded all its previous records, and had the other shipbuilding centres produced in the same proportion, the total of 1902 would have beaten all precedent. As it is, it has been a great deal too much for the comfort of the owners of cargo boats, although the building has given an amount of remunerative employment without which our commercial and social records would have been shockingly bad. The following is the production of the United Kingdom in 1902, as compared with 1901:—

SHIPBUILDING OUTPUT OF THE UNITED KINGDOM.

	1902.			1901		
	Vessels.	Tons.	I.H.P.	Vessels.	Tons.	I.H.P.
England	937	891,521	666,373	876	1,002,700	[illegible]
Scotland	404	567,886	533,128	376	554,400	472,190
Ireland..	27	150,033	107,100	23	151,022	[illegible]

The following shows the 1902 output of the leading shipbuilding districts of the world:—

	Vessels.	Tons.	I.H.P.
The Clyde	312	518,270	[illegible]
The Tyne	144	323,708	[illegible]
United States	162	314,894	[illegible]
Germany	250	[illegible]	[illegible]
The Wear	67	[illegible]	[illegible]
The Tees and Hartlepools	74	195,114	[illegible]

Leading Producers.

In 1901, in the list of shipbuilders, Messrs. Harland and Wolff were first for any single yard with an aggregate of 92,316 tons; while Messrs. William Gray and Co., West Hartlepool, were second with 82,262 tons; Messrs. Russell and Co., Port Glasgow, third, with 58,387 tons; Messrs. Workman, Clark and Co., Belfast, fourth, with 52,711 tons; and Palmer's Company, Newcastle-on-Tyne, fifth, with 51,292 tons. In 1902 the order of the six leading firms—not yards—was :—

	Tons.
Harland and Wolff, Belfast ...	79,407
Workman, Clark and Co., Belfast...	75,932
C. S. Swan and Hunter, Newcastle-on-Tyne	58,322
Russell and Co., Port-Glasgow ...	55,585
Armstrong, Whitworth and Co., Newcastle-on-Tyne	52,039
Wm. Doxford and Sons, Sunderland	43,780

Clyde Shipbuilding.

The following is a complete return of the output of each Clyde shipyard in 1902, and the correlative figures for 1901 :—

	SAIL.		STEAM.		1902.	1901.
	Vessels	Tons.	Vessels.	Tons.	Total tons.	Total tons.
Russell and Co.	—	—	15	55,585	55,585	58,387
C. Connell and Co.		—	9	41,052	41,052	36,876
W. Denny and Bros.	3	1,812	14	38,517	40,329	35,266
D. and W. Henderson	—	—	7	30,840	30,840	24,563
Barclay, Curle and Co.	—	—	8	31,280	31,289	10,072
The Fairfield Company		—	4	30,300	30,300	28,565
A. Stephen and Sons		—	6	27,826	27,826	21,906
John Brown and Co.		—	8	26,260	26,260	49,800
Napier and Miller		—	5	18,708	18,708	17,067
A. McMillan and Son	7	17,055	—	—	17,055	13,738
R. Duncan and Co.	-	—	4	15,613	15,613	14,031
W. Beardmore and Co. ...		-	3	15,258	15,258	17,390
Scott and Co.	—	-	3	13,804	13,804	13,074
London and Glasgow Company...			2	13,835	13,835	17,552
A. Rodger and Co....	4	10,137	3	2,584	12,721	10,074
Grangemouth and Grenock Company		—	5	12,404	12,404	12,666
Caird and Co. ..	—	--	2	11,024	11,024	13,387
A. and J. Inglis		-	4	10,875	10,875	12,204
W. Hamilton and Co.	1	1,951	2	7,000	9,941	18,272
D. J. Dunlop and Co.	1	217	2	8,453	8,670	5,433
Wm. Simmons and Co.	—	—	6	8,050	8,050	8,650
Fleming and Ferguson	—		9	6,400	6,400	5,400
Murdoch and Murray	—	—	5	6,083	6,083	2,117
John Reid and Co.	3	5,606	1	345	5,951	2,217
The Ailsa Company	1	1,760	7	4 150	5 910	6,665
The Clyde Company	—	—	4	5,103	5,103	4,265
Mackie and Thompson	—	—	14	4,103	4,103	6,377
Campbeltown Company ...			2	3,204	3,204	3,150
Alley and Maclellan	15	1,866	3	1,291	3,157	2,401
Bow, McLachlan and Co.	4	396	8	2,555	2,951	2,208
J. Fullerton and Co.	-	—	8	2,818	2,818	1,735
Ritchie, Graham, and Milne	9	660	8	1,686	2,346	2,050
The Ardrossan Company... ...	1	26	6	2,141	2,167	761
J. Shearer and Sons	—	–	3	1,462	1,462	966
Lobnitz and Co.	1	120	11	1,120	1,240	4,606
Scott and Sons	-	—	6	1,228	1,228	1,373
Geo. Brown and Co.		–	7	900	900	350
W. Chalmers and Co.	5	650	1	200	850	776
D. M Cumming ...	1	40	2	307	347	620
W. Fife and Son	8	200	—	—	200	230
Cochran and Co.	—	-	1	278	278	500
Peter Macgregor	—	—	2	104	104	—
J. and J. Hay	1	75	1	110	185	120
The Irvine Company	—	—	1	153	153	1,840
Hanna, Donald, and Wilson	-	—	2	83	83	--
W. Jacks and Co.	1	25	1	43	68	—
R. Macallister and Son ...	2	30	4	34	64	172
Other firms	5	50	7	48	98	362
	73	42,766	230	475,404	518,270	511,090

These two years are the largest on record. The next largest was 491,074 tons, in 1899. The output of 1892 was 336,414 tons; of 1882, 391,934 tons; of 1872, 230,347 tons; of 1862, 69,967 tons.

Tyne Shipbuilding.

The Tyne, like the Clyde, managed to better its 1901 record. It was late in the season before the depression now so general on the North-east coast took effect on the yards, and it does not, therefore, tell on the output of last year. Wages have come down, and the operatives have in most cases accepted the reductions, recognising that this is their share of a falling market. The strike of joiners has, however, caused a good deal of inconvenience, and some builders state that but for this they would each have had another vessel in this year's figures. Among the notable Tyne launches of the year mention may be made of the twin-screw cable steamer *Colonia*, built by Messrs. Wigham-Richardson and Co. This vessel left the Thames in July to lay the Vancouver-Fanning Island section of the new Pacific cable, and, loaded with 3,540 knots weighing 7,684 tons, she arrived at Vancouver Island on September 12th, and laid 3,455 knots without an accident of any kind. This is the longest length of cable ever laid. The Tyne list also includes the Wilson-Furness-Leyland Liner *Hanoverian* (now *Mayflower*), the largest yet built in the district, and the Durban floating dock, built by Messrs. Swan and Hunter, which was wrecked on the way out The following are details of

THE TYNE OUTPUT.

	Total. Vessels	Tons.	[illegible] Tons.
C. S. Swan and Hunter ...	11	58,322	[illegible]
Armstrong, Whitworth and Co.	13	52,030	30,507
Wigham-Richardson and Co. ...	12	37,355	30,701
Palmers' Company ...	6	31,313	[illegible]
Hawthorn, Leslie and Co.	5	26,658	[illegible]
The Northumberland Co.	6	24,790	[illegible]
John Readhead and Sons	8	24,764	[illegible]
R. Stephenson and Co. ...	9	15,904	13,580
The Tyne Company ...	5	15,271	[illegible]
Wm. Dobson and Co. ..	6	13,740	12,828
The Blyth Company	4	9,352	8,025
Wood, Skinner and Co....	5	6,490	[illegible]
Smith's Dock Company...	31	3,725	[illegible]
J. T. Eltringham and Co.	9	1,770	[illegible]
J. P. Rennoldson and Sons	8	1,632	[illegible]
Hepple and Company ...	2	240	120
John Lindsay ...	3	175	—
W. P. Huntley ...	1	66	[illegible]
The Union Company ...	—	—	[illegible]
	144	[illegible]	313,137

Other English Productions.

The returns from the English yards show an increase of 61 vessels over last year, but a decrease of over 200,000 in tonnage, and over 220,000 in horse-power. The increase in vessels is mostly in the Thames district, and the decrease in tonnage in the Tees and Hartlepools. The following table summarises the work in England during the year:—

	1902.			[illegible]		
	Vessels.	Tons.	I.H.P.	Vessels.	Tons.	I.H.P.
The Tyne ...	144	323,705	[illegible]	128	313,137	[illegible]
The Wear ...	67	230,670	159,450	77	[illegible]	[illegible]
Tees and Hartlepools	74	105,114	111,000	88	[illegible]	[illegible]
The Dockyards ...	5	51,500	12,500	8	[illegible]	1,400
The Thames ...	306	29,181	51,129	271	[illegible]	[illegible]
Western Ports	67	27,022	19,165	66	[illegible]	[illegible]
The Humber ...	120	26,442	24,135	81	[illegible]	[illegible]
English Channel Ports	147	6,704	12,829	152	6,230	6,008
Bristol Channel Ports	7	1,063	605	5	[illegible]	[illegible]
	937	891,521	[illegible]	876	[illegible]	[illegible]

Marine Engineering.

The output by marine engineers in the United Kingdom during 1902 aggregated 1,309,500 i.h.p., as against 1,471,788 i.h.p. in 1901. The table given below shows the leading marine engineering firms for this year in the order of their i.h.p. :—

	I.H.P.
The North-Eastern Marine Company, Wallsend and Sunderland	85,845
Richardson's, Westgarth and Co., Middlesbrough, Hartlepool and Sunderland	78,050
Hawthorn, Leslie and Co., Newcastle-on-Tyne	65,000
The Wallsend Slipway Company, Newcastle-on-Tyne	62,550
Harland and Wolff, Belfast	60,200

The Armstrong Company.

In connection with the Tyne returns, it may be mentioned that Sir W. G. Armstrong, Whitworth and Company, Ltd., Newcastle-on-Tyne, during the past fifty years have built 732 vessels of nearly one million tons gross, and over one million indicated horse-power. The ships built comprise war vessels, passenger and cargo vessels, ice-breaking steamers, vessels for the carriage of petroleum in bulk, suction dredgers, railway ferry steamers, and vessels of various types. The following table gives particulars of the various classes of vessels constructed at their Walker and Elswick Shipyards from 1852 to 1902 :—

	No.	Tonnage.	I.H.P.
Passenger and cargo steamers	379	518,038	284,131
War vessels	103	186,129	548,255
Paddle steamers	92	24,624	29,106
Petroleum steamers	77	220,357	108,636
Ice-breakers, dredgers, and vessels of various types ...	81	49,340	35,250
Totals	732	998,488	1,005,378

World's Output.

The following table summarises the entire work in the year in the world, according to available returns :—

	1902.			1901.		
	Vessels.	Tons.	I H P.	Vessels.	Tons.	I.H.P.
Scotland	404	567,886	533,128	376	554,406	472,190
England	937	891,521	669,373	876	1,092,760	890,298
Ireland	27	159,633	107,100	23	151,922	109,300
United Kingdom totals...	1,368	1,619,040	1,309,601	1,275	1,799,088	1,471,788
British Colonial	86	24,700	10,815	72	9,394	11,114
Foreign	939	1,054,907	717,717	845	954,803	790 476
Grand totals ..	2,393	2,698,647	2,038,133	2,192	2,763,285	2,273,378

From England to Australia in Fourteen Days.

Five-and-twenty years ago it was prophesied that the time would come when one would be able to accomplish the journey from London to Melbourne in sixteen days. This prediction is certainly likely to be verified by the completion of the great Siberian Railway, which stretches from Moscow to Port Arthur, connecting up a line which spans the continent from Calais to the coast of China. This, the greatest expanse of steel rails known to the railway world, is almost equal in mileage to the United States and Canadian-Pacific lines put together, and, like them, has been constructed at the rate of over a mile a day, the rails of each mile—at first roughly laid—being instantly utilised to transport material for the construction of the line ahead. The work of relaying the track with heavier rails and strengthening the permanent way is being pushed on with astonishing rapidity.

The London-Shanghai Journey.

The present sixteen days' journey from London to Shanghai is made at the very moderate rate of twenty miles an hour. M. de Passek, the Imperial Consul-General for Russia in Australasia, however, assured a deputation that as Russia was resolved to spare no effort to make the Siberian Railway the main highway between the West and the East, the line would be brought up to the European standard of speed at the earliest possible time. As events are shaping, it is more than probable that within the next four or five years passengers and mails from London will be delivered at Port Arthur within eight days. According to announcements the line to Port Arthur will be opened to direct traffic with European railways early in this year, when passengers from the great European towns will be able to book right through to the various Chinese and Japanese cities.

Proposed Adelaide-Port Darwin Line.

A passage between Port Arthur and Port Darwin in the north of Australia can be made by a vessel possessing the speed of the ordinary trans-Atlantic boats in six days. There is, however, no communication by rail between Port Darwin and the important Australian centres. To get over this difficulty it has been proposed to construct 1,063 miles of single track railway, on a gauge of 3 ft. 6 in. with 60 lb. steel rail, to bridge the tremendous gap between the respective railheads of Adelaide (South Australia) and Port Darwin, thus running right through the centre of the Australian continent. South Australia can, without putting her hand in her pocket, secure the construction of the line on the land grant principle, and by this means assure the prosperity of her valuable northern estate, not to mention the many benefits that would accrue from her position as Australia's channel of communication with all the world.

American Railway Systems.

In the course of a critical review of American railways, a correspondent of the *Times* points out the fundamental differences which exist between British and American systems. The most striking perhaps is to be found in their respective mileage. The total length of completed railways in the United States in 1901 was 198,787 miles, whereas the length of line open for traffic in the United Kingdom on the same date was 22,078 miles. Although the mileage of American railways is greatly in excess of that of our own, the density of passenger traffic in Great Britain is, of course, far greater than in the United States. Taking the year 1900, for example, the number of passengers carried (exclusive of season ticket holders) on British railways was 1,142,000,000, while the railways of the United States, with nine times the mileage of British railways, carried only 576,000,000.

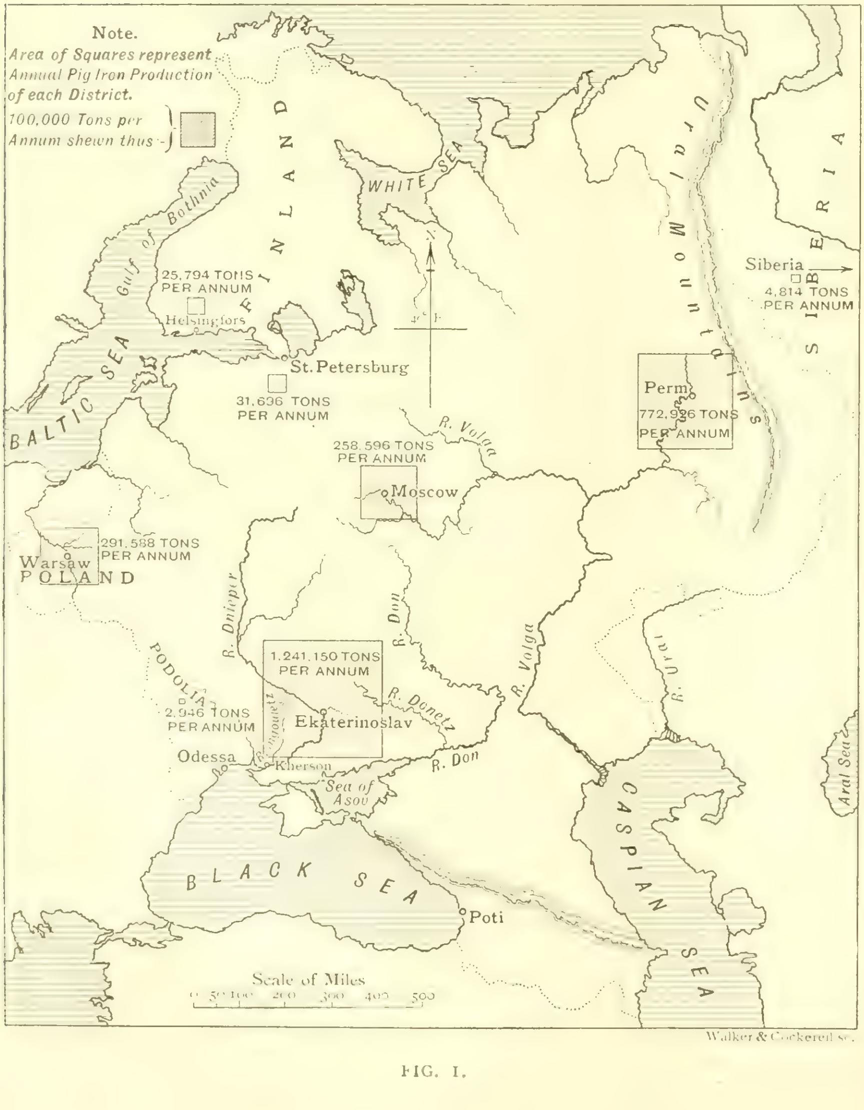
The Crude and the Perfect.

It is remarked that there is an odd admixture of the crude and the perfect that strikes one in the working of American railways. The traveller in the United States is most favourably impressed with the size, beauty, and general arrangements of the terminal stations of the great American lines, and when he takes a seat in a Pullman car to begin, say, a journey across the American Continent, he may think he has reached a country which represents the highest type of railway development. But before he has gone many miles he will considerably revise his opinion. When travelling in America one gets the curious impression that American railways are both in advance of their times, and two or three decades out of date. In no respect are American railways more behindhand than in "grade" crossings. What is much worse, however, is the absence of overbridges or tunnels to enable the passenger to cross safely from one side of the station to the other. The unfortunate passenger is obliged to walk over the lines, dodging any passing trains or stray locomotives as best he can.

Taken on the whole, American railroads suggest a much lower standard of completeness than those of England. Americans are of opinion that the British system may suit a country like Great Britain, but they believe that the American method of beginning in an unpretending style and effecting betterments later on, suits a young country like America better than English methods would. There is no doubt, however, that the safety of the American public has long been endangered by the numerous level crossings, the absence of overbridges at stations, and the various other risks and perils which have grown up with the American railway system. Under these circumstances it is gratifying to know that the work of betterment on many of the lines is already in progress.

NOTABLE BRITISH PAPERS OF THE MONTH.

A Monthly Review of the leading papers read before the various Engineering and Technical Institutions of Great Britain.



Walker & Cockerell sc.

FIG. I.

THE SOUTH RUSSIAN IRON INDUSTRY.

BY

ARCHIBALD P. HEAD, M.Inst.C.E.

IN August, 1901, the author visited the South Russian iron district to report on certain iron, coal, and manganese mines and blast furnaces, and enjoyed exceptional facilities for examining these industries from a metallurgical as well as from a commercial standpoint. The present paper is founded on the result of his investigations, and was read before a recent meeting of the Society of Arts.

The production of iron in South Russia has made rapid strides in recent years, and this region is now by far the most important of the eight iron-producing districts in Russia, both European and Asiatic. The following table shows their relative importance, on the basis of the production of pig-iron:—

PRODUCTION OF PIG IRON IN RUSSIA.

District.	Tons in 1899.* (Based on first half year.)	Percentage of total.
South Russia... ...	1,241,150	47·3
Ural	772,926	29·44
Poland	291,588	11·0
Moscow	258,596	9·8
North	31,696	1·2
Finland	25,704	0·97
Siberia	4,814	0·18
South-West	2,946	0·11
Total ...	2,629,510	100·00

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* The figures for 1900 show that while the total annual production only advanced to 2,850,256 tons, the South produced 51·7 per cent. of the total, and the Ural district remained practically stationary.

For comparison :

	[illegible] Tons.
United States	[illegible]
United Kingdom	9,300,000
Germany	[illegible]

Fig. 1 shows the same facts in graphic form. It will be seen that the Ural district, which is generally supposed to be the great Russian iron centre, has now lost its supremacy. The more rapid progress made by the Southern district is shown by the fact that whereas the increase of production of pig iron in the Urals between 1895 and 1899 was 45 per cent., that of the South was 130 per cent. during the same period.

In the production of finished steel, the South shows a

TABLE A.—IRON AND STEEL WORKS IN SOUTHERN RUSSIA.

Name of Works.	Where.	Ref. No. Plans.	Source of Capital.	Paid up Capital.	Date of Starting.	Products.	No. of Blast Furnaces.	Production during 1900. Pig Iron Tons.	Production during 1900. Finished Iron and Steel Tons.	Total Tons.	Average No. of Workmen Employed.
Column 1	2	3	4	5	6	7	8	9	10	11	12
Hughes, or New Russia Co.	Hughesofka	1	English	£ 900,000	1869	Pig iron and steel	7	267,820	159,030	426,850	8,319
Dnieprovienne, or S. Russian Co. ...	Kamenskoie	2	Belgian & Russian	764,440	1889	do.	5	209,980	170 580	380,560	6,330
Briansk Metallurgical Co.	Ekaterinoslav	3	Russian	1,701,005	1887	do.	5	145,780	107,790	253,570	7,068
Russo-Belge Metallurgical Co..........	Volintsevo	4	Russo-Belgian	1,579,296	1895	do.	3	150,150	122,255	272,405	2,713
Donetz - Urievka Metallurgical Co.	Urievka	5	Russo-German	845,883	1895	do.	5	109,510	31,000	140,510	3,630
Drushkova, or Donetz Iron and Steel Co.	Drushkova	6	French	702,810	1894	do.	3	94,770	79,020	174,300	2,411
Taganrog Metallurgical Co..........	Taganrog	7	Belgian	1,189,522	1895	do.	3	79,148	62,350	141,504	[illegible]
Nicopol - Marioupol Mining and Metallurgical Co.	Marioupol	8	German and Russian	789,684	1896	do.	2	76,770	37,410	114,180	1,700
Pastoukof, or Soulinskie Works	Souline	9	Private	...	1869	do.	3	38,738	25,284	64,022	[illegible]
Russian "Providence" Works ..	Marioupol	10	Belgian	1,784,189	1898	do.	3	72,335	47,135	119,470	1,072
Makievskaia Works	Makievskie	11	...	...	...	do.	2	47,080	16,664	63,744	[illegible]
Gdantsevski, or Krivoy Rog Iron Mining Co.	Krivoy Rog	12	French	...	1892	Pig Iron	3	52,038	...	52,038	[illegible]
Olkovaia Iron Smelting Co.	Ouspensk	13	Belgian	297,365	1896	do.	2	76,277	...	[illegible]	[illegible]
Krematorskova Metallurgical Works	...	14	...	...	...	do.	2	15,050	...	[illegible]	[illegible]
Almaznaia Colliery Co.	Almaznaia	15	Belgian	...	1900	do.	2	14,688	...	[illegible]	[illegible]
Kertch Metallurgical Works	Kertch	16	...	...	...	do.	2	[illegible]	...	[illegible]	[illegible]
Verkhne Dnieprovienne Works.....	Ekaterinoslav	17	Belgian	515,432	...	do.	1	...	...		...
Bielaia Blast-Furnace Co.	Bielaia	18	Belgian	396,486	New	do.	2				
						Totals ..	55	[illegible]*	[illegible]*	[illegible]	

* Later corresponding figures are as follows :—Pig Iron—1901, [illegible] tons ; 1902 (rate of) [illegible] tons. [illegible] Steel—1901, 984,000 tons ; 1902 (rate of), 894,000 tons.

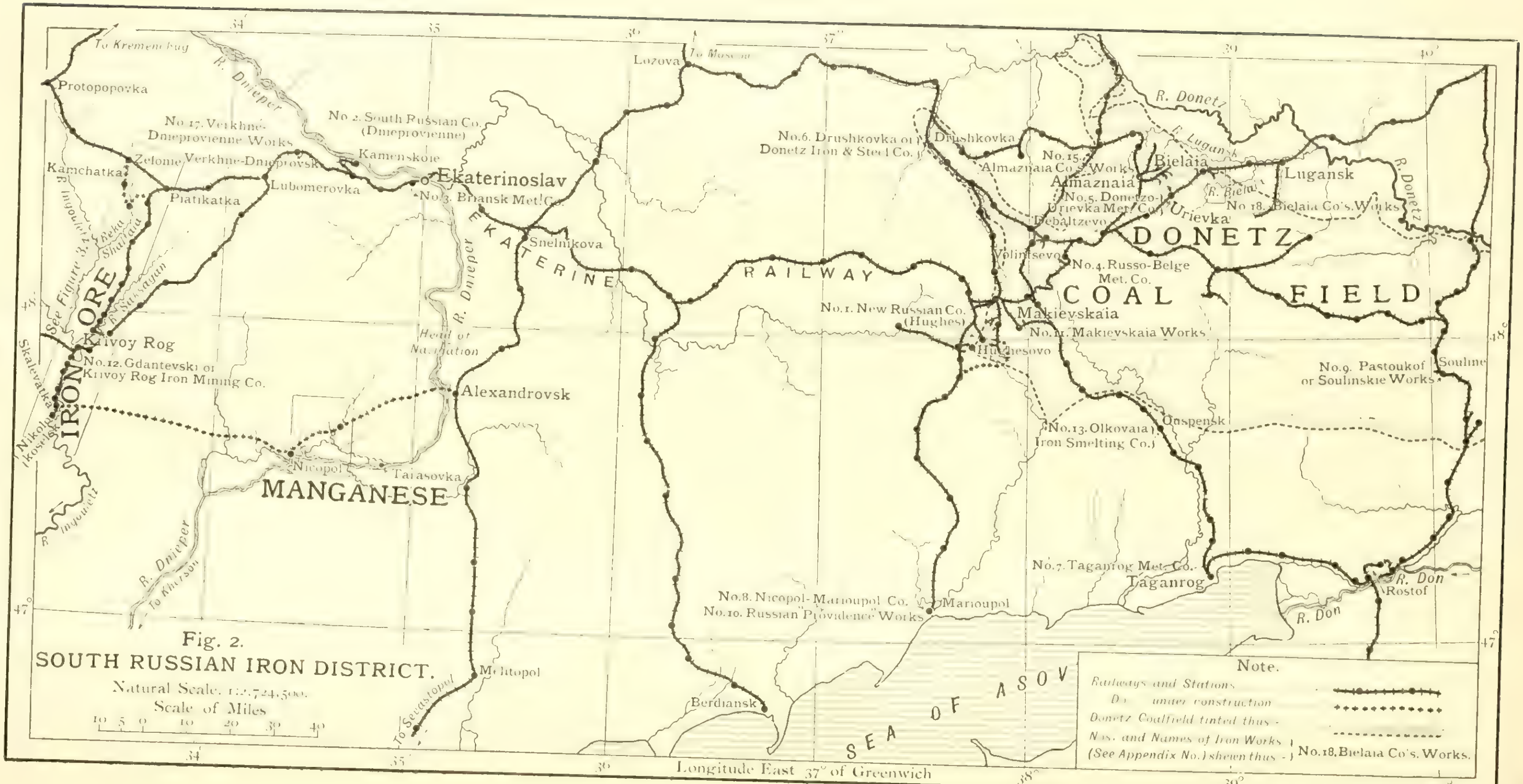

Fig. 2.

SOUTH RUSSIAN IRON DISTRICT.

Natural Scale. 1:2,724,500.

Scale of Miles

Walker & Cockerell sc.

still greater supremacy over all other districts, as follows:—

PRODUCTION OF FINISHED STEEL IN RUSSIA.

District.	Tons in 1900.	Percentage of Total.
South Russia	843,950	58·64
Ural	181,950	12·63
Poland	203,910	14·14
Moscow	123,620	8·60
North	86,280	5·99
Total	1,430,710	100·00

After describing the local topography, the author proceeds to analyse the quality of the ore, and to deal with the railway communication. He then mentions the blast furnaces and steel works where the finished article is produced.

Table A gives a list of the 18 chief iron and steel works in the South, together with various particulars as to capital and nationality. From column 6 it will be noticed that most of these works have been built since 1892, and are therefore quite modern. Column 4 shows that Belgian capital largely preponderates. Although the first works in this district (the New Russia Company) were started in 1869 by an Englishman, Mr. Hughes, very little English capital has flowed in the same direction. It is different with Belgian capital. Since the establishment of the first Belgian company, the Dnieprovienne, or South Russian Company (associated with Messrs. Cockerill, of Seraing, Belgium), there has been a constant influx of Belgian capital. Out of the most important works enumerated, at least eight are partially or entirely Belgian capital, while out of the total number of 55 blast furnaces, 21 are Belgian.

The author personally visited five of these works, viz.: Briansk, Donetz-Urievka, Gdantsevski, Almaznaia, and Bielaia, and was much struck by the good, substantial, and well-constructed nature of the work. Generally speaking, the structural portions of the works have been built in Russia, and the machinery in Belgium, Germany, or France, or to a small extent in England and America.

There is, perhaps, an absence of labour-saving appliances in the blast furnaces, notably in the handling of materials between the stock piles and the furnace top. But it must be remembered that Russia is different from Western Europe and America, in the scarcity of skilled mechanics for the maintenance of machinery. Mechanical instinct is not a conspicuous quality among Russians, and the care and foresight exercised by those in charge of machinery is too often regulated solely by the amount of supervision and discipline to which they are subjected. Consequently, there is not only a great liability for machinery to go wrong, but great difficulty in repairing it. If to this be added the cheapness of manual labour, there are sufficient reasons for the avoidance as far as possible of all complicated machinery. Generally speaking, a proper mean course has been followed between too much mechanism on the one hand and too wasteful an expenditure of labour on the other hand. After making due allowance for these conditions, the design and workmanship of some of the most modern blast furnaces and accessory appliances leaves little to be desired, and bears comparison with some of the best plants in Europe. The *personnel* are as a rule of the nationality of the owners. Thus in works of Belgian or French capital the director and departmental managers are Belgians or Frenchmen respectively. In Russian works, on the other hand, positions of responsibility are largely occupied by Poles. The workmen are in all cases Russian.

It will be seen that of the 18 important works in South Russia enumerated in Table A, all make pig iron, in a total of 55 blast furnaces, and 11 are steel makers in addition. The works are not concentrated in manufacturing centres, but scattered along the Ekaterine Railway. The whole country is what is known as Steppes, viz., extensive undulating plains, entirely treeless, except by the edges of streams and rivers. Every eminence is crowned by a tumulus, said to have been erected in olden times, either to repel the Tartar invasions or as a burial place for chiefs. The scattered nature of the works and the comparative scantiness of population, as well as the want of enterprise of private builders, makes it necessary for each company, whether mining or metallurgical, to erect colonies for their workpeople, which generally consist of comfortable houses varying in accommodation from the eight-roomed house, containing four unmarried men per room, to the sumptuous mansion of the director. The rainfall is small, being about 11 inches per annum, due to the treelessness of the land. This necessitates elaborate and expensive arrangements for water supply at most works. At one blast furnace plant visited by the author, an artificial lake has been made, 97 acres in area, holding 143 million gallons of water, and situated 200 feet below the blast furnaces to which water is pumped in two stages by electrically driven pumps.

Import Duties.—There is an import duty into Russia on ordinary pig iron by way of Black Sea ports of £2 19s. 5d. per ton, which is sufficient to keep out foreign competition. An excise duty of 2s. per ton of Russian-made pig iron was abolished by the Government in 1901, in order to afford some relief to the harassed trade. On account of the heavy import duties pig iron has been imported in but small and decreasing quantities, as follows: 1900, 51,000 tons; 1901, 29,700 tons; 1902, at the rate of 14,520 tons.

The import duty on ferro-manganese and spiegeleisen is £4 19s. per ton, which is sufficient to keep out English made spiegeleisen, but not sufficient to keep out English-made ferro-manganese, which latter can be sold in South Russia at about £2 per ton below market price, and which is sent regularly from England by way of Black Sea ports at the rate of about 4,250 tons per annum. At the present time, speigeleisen and ferro-manganese are being made in Russia at five of the works enumerated in Table A. The import duties on finished steel products are as follows: Steel ingots and plates, £5 18s. per ton; merchant iron, £5 18s. per ton; [illegible] to £9 18s. per ton.

Government Control.—The Government [illegible] very real and somewhat paternal control over the mining companies for the protection of the workpeople, employing an army of officials for the purpose. All companies are obliged to supply a Government mining engineer, and are subject to periodical visits by Government inspectors. The companies are obliged to provide proper accommodation for the operatives in the way of houses, hospitals, churches, etc., and the slightest accident resulting in injury to any workman is the subject of Government inquiry. The employers appear to live in dread of accidents, on account of the troublesome investigations which invariably follow.

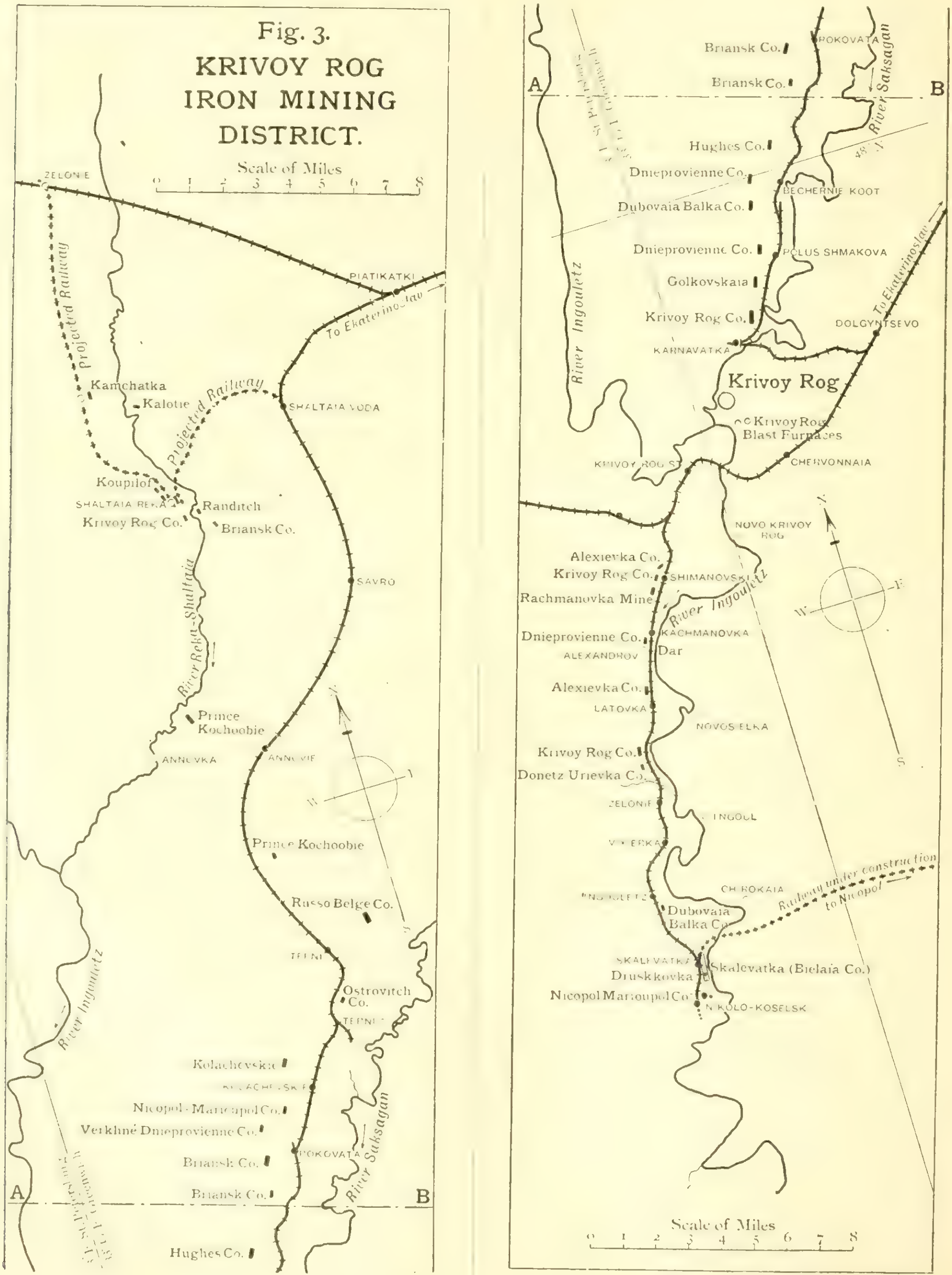
Fig. 3.
KRIVOY ROG IRON MINING DISTRICT.

Walker & Cockerell sc.

Steel Works.—The eleven steel works in South Russia are, as a rule, well equipped with modern machinery. Both the open hearth and Bessemer processes are used for conversion of pig iron into steel. The finished product may be classified as follows :—

	Per cent. of total steel production.
Railway materials (rails, fish plates, tyres and axles)	47·5
Merchant bars, sheets, columns ...	37·2
Miscellaneous	15·3
	100·0

The present market prices of finished steel products are: Rails, £8 5s. per ton; rolled joists, £5 15s. 6d. per ton; merchant iron, £8 5s.

(*To be continued.*)

THE RUPNARAYAN BRIDGE, BENGAL-NAGPUR RAILWAY.

A PAPER on this important bridge, built by the Bengal-Nagpur Railway, and forming part of the direct east-coast line between Calcutta and Madras), was recently contributed to the Institution of Civil Engineers by Mr. S. Martin-Leake.

The Rupnarayan was both a river and a tidal creek. The total discharge had been estimated to be 563,530 cubic feet per second, with a velocity of 10 ft. per second. The river was embanked on either side, and the flood-level was considerably higher than the surrounding country; the greatest depth of water before work commenced was 17 ft. below low water. The bridge consisted of seven spans of 300 ft. (314 ft. 6 in. from centre to centre of piers) and four spans of 100 ft., two at each end. The piers were all built for a double road, but girders for one road only had been erected.

The piers for the larger spans were founded on steel caissons, 88 ft. in height, 63 ft. in length, and 22 ft. in width, with semi-circular ends. Each caisson was divided by means of cross bulkheads into three dredging-chambers, 13 ft. 6 in. in width. The inner plates of the bottom 12 ft. were inclined to a cutting edge, and formed the shoe. Above the shoe, the caisson was built up of rings 4 ft. in height, connected together by horizontal angle-bars; each ring could therefore be erected complete, lifted into position, and riveted to the caisson, thus saving time. Each caisson weighed 385 tons.

The river-bottom consisted of a layer of hard blue clay, covered on the east side with silt; this clay extended to a depth of about 10 ft. Below the blue clay, yellow clay varying in quality, was met with to a depth of 55 ft.; below this was sand, and in this sand the caissons were founded. Caissons Nos. 1 and 8 were sunk from ground-level; Nos. 5, 6 and 7 from islands; and Nos. 2, 3 and 4 were lowered and sunk from a floating staging erected on flats.

Work commenced on No. 1 caisson (on the west bank) in August, 1897. At first the sinking was carried on by men inside the caisson, the clay sunk through being impervious to water; but at a depth of 16 ft. the external pressure was found to be bulging the side cutting-edges inwards; dry sinking was therefore stopped and the caisson filled with water. No further attempt at dry sinking was made with any of the caissons. Further sinking was done with dredgers. At a depth of about 78 ft. the caisson hung badly and refused to go down; holes were excavated below the cutting edge, and some of the internal water was baled out, the caisson then began to move, going down 9 ft. in 4 hours. Baling out some of the water after excavating holes below the cutting edge was found to be a certain method of moving the caissons whenever they refused to follow the dredging. Bruce and Batho dredgers, each having a capacity of 30 cubic feet, were used, one in each of the three dredging-chambers. The dredgers were suspended from a horizontal timber supported by a staging of old rails, stiffened with angle-bars. As the caisson sank and more rings were added, lengths of 8 ft. were added to the verticals and the lower stiffening bars were disconnected and refixed to the newly added lengths. The verticals were built in as the masonry filling of the caisson advanced in height. Thus no time was lost in dismantling and re-erecting staging each time the caisson was added to. The staging remained permanently in position. The sinking of No. 1 caisson was completed in August, 1898.

In October, 1897, islands were constructed for caissons Nos. 6 and 7 by driving piles about 5 ft. apart, enclosing a space, similar in shape to the caisson, but allowing 5 ft. clear all round. Outside sand-bags were heaped against the piles, the inside being filled with silt, and on this the caissons were erected. The sinking was done with dredgers. The three steam-hoists working the dredgers were contained in a large barge, moored alongside the caisson. Caisson No. 6 was completed in September, 1898, and No. 7 in August, 1898; caisson No. 5, also sunk from an island, was commenced in December, 1898, and completed in September, 1899. As soon as these caissons were known to have entered the blue clay the tides were allowed to wash away the islands.

It was not possible, without incurring great expense, to make islands for caissons Nos. 2, 3 and 4, the tides running very strong at their sites. These caissons had therefore been lowered from a floating staging. Two ordinary river flats, 180 ft. by 26 ft. by 9 ft., had been purchased in Calcutta; these were placed 24 ft. apart, and carried the staging required. The staging consisted of two parts, the forward position, 40 ft. in height, being used for lowering and sinking the caissons. The height was necessary in order to clear the caissons at low water during sinking; the after portion, 20 ft. in height, was used for erecting the rings on; three rings could be erected complete on it at one time. The staging was made of Oregon pine, a special consignment of which was obtained from America. The caisson-shoes were erected and made watertight on a temporary platform placed over the space between the flats. Each shoe, weighing 75 tons, was lifted by means of sixteen 10-ton Weston pulleys suspended from the top of the staging, each group of four [illegible] placed under the cutting edge by means of equilibrium bars. The shoes, having first been raised sufficiently to allow the platform to be removed, were then lowered into the water until a part of the weight was carried by flotation. Rings had then been added until the total height of caisson was sufficient to keep the top above water at high tide after pitching. The caisson was then ready to ground. Previously the moorings of the flats had been adjusted daily. At the top of the tide the caisson was lowered sufficiently to allow the cutting edge to ground as the tide fell, and any final adjustments for position and span to be carried out. As soon as the loads were taken off the hooks the lowering tackle was disconnected and water admitted into the caisson. No difficulty was found in pitching the three caissons on their exact sites. Caissons Nos. 2 and 4 were sunk by means of Sir Bradford Leslie's boring plant, No. 3; after pitching, by dredgers. The plant consisted of a boring-head with four arms, 10 ft. in total diameter, rotated by means of an annular pipe 26 in. in external and 13 in. in internal diameter, bolted together in 8-ft. lengths, driven by a small steam-engine fixed to a gear-box bolted to the caisson. Over the side of the caisson was a siphon, one leg running down the 13-in. pipe, the other into the river. Water was pumped into the dredging-chambers by two 13-in. centrifugal pumps. When working, the water due to the head maintained by these pumps flowed up the rotating shaft through the siphon into the river, carrying with it the mud, etc., cut away by the boring-head. Caisson No. 2, commenced in December, 1897, was founded in August, 1898; No. 3, started October, 1898, was founded in August, 1899; and No. 4, started December, 1898, was founded in January, 1900. Caisson No. 4 gave considerable trouble in sinking when only a few feet into the river-bed, and after it had been built up to a height of 40 ft., it one day suddenly tilted over until it was 5 ft. 9 in. out of plumb. It was eventually straightened, but finally was founded about 2 ft. to the west of its proper position. None of the other caissons were more than 9 in. out in any direction. The tops of the caissons were taken down to low-water level.

The girders were of a semi-bowstring type, each span weighing 546 tons. They were erected on two pontoons of steel, 280 ft. by 40 ft. by 10 ft. These were built in Calcutta and designed so that they might afterwards be used for the waggon-ferry over the Hugli in Calcutta. Each span was erected complete on the decks of the pontoons and then floated over the piers at high water, the piers having previously been built only to a height of 18 ft. above low water. As the tide fell the pontoons floated away and left the span supported on packings. The remaining 15 ft. in height of the piers had been built as the spans were lifted. The lifting was effected with 150-ton hydraulic jacks. To obtain as much room as possible the spans were placed alternately on the sites of the up and down roads, and, when at the full height, those on the site of the down road were traversed over into line with the others. All the bricks and lime used on the works were burnt at the bridge site. The total weight on the base of each pier was 8,697·5 tons, or 6·7 tons per square foot.

The actual construction was commenced in August, 1897, and the bridge was tested and passed by the Government Inspector on the 1st May, 1900.

ELECTRIC AUTOMOBILES.

IN his introduction to a paper on "Electric Automobiles," read before the Institution of Civil Engineers, Mr. H. F. Joel said that this was possibly the most practical, and certainly the most interesting, form of motor car.

These had now become thoroughly practical vehicles, journeys of over 100 miles on one charge, and tours of over 1,000 miles (from London to Glasgow and back) having been satisfactorily accomplished. Electrical energy was power in an economical and readily applied form, the application of which gave rise to no noise or smell, made no refuse, and was convenient. It also afforded facilities for braking power and recuperation of energy which were not obtained with other sources of energy.

It was only since the passing of the Locomotives on Highways Act, in 1896, that the problem of motor-cars had been seriously attacked in this country. In Germany, France, Austria, America, Italy, Spain, Belgium, and many other countries, earnest attention was being given to the manufacture and the perfection of electric vehicles, and in most of these countries inventors and designers were assisted by their governments directly by subsidies, by official trials, as in Berlin, or otherwise. In England it had been left entirely to the enterprise of the private individual to compete with the foreigner for a share at least in this new and important industry, which even now gave employment to some 10,000 men in this country.

Tabulated examples of recent long-distance runs of carriages propelled by one charge were given, and these records were analysed for comparison, elevations and plans of the carriages being shown to scale, and the disposition of the batteries indicated. As these were all special designs and not merely adaptations of carriages, they were instructive as examples. The author then considered briefly, in turn, the leading points in connection with the various parts of an electric automobile, namely, the storage-batteries, or accumulators, motors and gearing controllers and circuits; underframes, types of vehicles, design and construction of carriage and proportion of power to load; as well as the comparative costs of electric and other motor cars.

Some very careful tests to determine the durability of storage-batteries were made by the Automobile Club of France in 1899, extending over six months, the results of which were given in the paper.

The tests had been made under conditions analogous to those that would occur in the carriages in practical use. The sets of batteries had been equally charged with 24 ampères at 2·5 volts per cell, but had been discharged at rates varying from 20 to 100 ampères, with intermediate periods of rest, and whilst being discharged they had been subjected to artificial vibrations, to give the effect of road vibrations, and this treatment had been continued until the cells had shown signs of failure.

RATIO OF WEIGHT OF VEHICLE TO WEIGHT OF STORAGE-BATTERY.

Generally speaking, as the ratio of the battery to the vehicle increased, so the distance the vehicle could be run on one charge was increased. But of greater importance, from a practical point of view, was the load-carrying capacity, and ratio of the weight of useful load to the weight of the battery and vehicle. A battery of accumulators weighing 6 cwt. would give 10 h.p.-hours, or 67·2 lb. weight of battery for 1 h.p.-hour, taking the efficiency of the motor and gear at 75 per cent. Assuming an output of 15 watt-hours for 1 lb. of complete battery, such a battery would convey itself against a tractive resistance of 50 lb. per ton (or 1/45), at the rate of 12 miles per hour, for a total distance of 250 miles. If the vehicle to convey this battery weighed 6 cwt., the distance that could be run with vehicle and battery would be 125 miles; and with a load of 3 cwt. (driver and passenger) the distance would under the same conditions be reduced to 100 miles, equal to 75 ton-miles. With twice the load, or 6 cwt., the distance of the run would be reduced to 83·8 miles, but the ton-mileage would be the same; and with three times the load, namely, 9 cwt., the distance would be still further reduced to 71·4, also equal to 75 ton-miles. The cost of carrying the useful load would be, for the 3 cwt. load, at the rate of 1·8d. per ton-mile; for the 6 cwt. load, 1·1d. per ton-mile; and for the 9 cwt. load, 0·9d. per ton mile. The conclusion would be that, as the load was increased, the cost of conveying the useful load per ton-mile was reduced; this was so, but the limit was soon reached when the vehicle must be made stronger and heavier to carry the increased load, and the running cost of the whole would be increased, as well as the first cost and the consequent allowance for depreciation and interest. Curves were given in the paper showing the ton-mileage, in conjunction with the ratio of weight of battery to the total weight; the ratio of useful load to the total weight; the cost of electric energy per ton-mile of useful load; the cost of electric energy for running the car and battery without load; and also the relative weights and costs of cars.

In America batteries were made which gave a very great output with a comparatively shortened life of the positive plates, and as these batteries were of comparatively small cost they could be entirely renewed, say, each year, and this had been stated to result in economy.

The author considered that potentialities of electric propulsion of carriages on common roads were very great. England had been late in taking up the motor-car, and France, America, Germany, and other countries were far ahead, but it was to be hoped that England would now take its place in the world with this new industry, as it had done in the past with the steam locomotive.

TECHNICAL EDUCATION.

At the tenth annual general meeting of the Association of Technical Institutions, Sir J. Wolfe Barry, K.C.B., LL.D., F.R.S., in the course of his presidential address, made some interesting remarks on the subject of Technical Education. Discussing its progress in England, America, and Germany, he remarked that if the public opinion of this country were as firmly convinced on technical education as that of Germany and America there could not be that want of funds which they now sorrowfully recognised. What was wanted, above all things, was to convince their manufacturers of the extreme value of technical education.

BRITISH TRADE.

At the same time he cautioned them against any exaggeration in estimating the influence of technical education on trade competition. It was of the greatest weight, but he mentioned several other reasons for the great development of German and American commerce during the past twenty or thirty years. His remarks on the present position of British trade were significant.

In spite of well-grounded alarms, our feet had not at present been very badly pinched by the shoes of the competition of other countries; the Board of Trade returns did not indicate—what we often heard of—the decadence of British trade. Up to now this country was holding its own, both in excellence of work and in its volume. He did not say that she would continue to do so, but, on the contrary, he recognised real dangers. He thought, however, that another main reason why we had been and still were backward in getting on equal terms with our competitors in matters within our control—for example, in technical education—was due to the fact that the sharp pinch of necessity had not yet absolutely come. That it would come, and come sharply, if we did not mend our ways he had little doubt.

RESEARCH TO BE STIMULATED—OUR NEEDS.

He ventured to say that, first, we wanted to render available the highest intellects among us for research as applied to the arts, and, secondly, to discover and utilise the best possible directing minds in our manufactures. As a means to these ends we must educate widely. We wanted to see in Great Britain the man of science installed in his laboratory in most important manufactories and encouraged to help in their developments. We desired to see in this country what was so observable in

America—namely, that almost everyone was a mechanic and knew something of applied science, valuing it, as was the case in Germany, as the handmaid of commerce apart from its inherent charm. We wanted to obtain our men at their best—when they were young, but not so young as to be without experience. Our object ought to be to turn out our best men fully equipped in every kind of scientific and practical education at from 28 to 30 years of age, and then "to give them their head." A man like this would know when to discard obsolete methods, to get rid of wasteful machinery and still more wasteful hand or animal labour, and to march with the time—to walk with certainty and not haphazard.

TECHNICAL EDUCATION NOT TO BE TOO EARLY.

He proceeded to suggest that our present methods required amendment, and, criticising the education afforded at public schools, said he hoped he should not be thought to suggest that some training in Latin or Greek was of no value.

He thought quite differently. But why drive every one along the same road, and why spend seven or eight years of a most receptive time of life in the impossible task of trying to make every one a classical scholar? Surely, out of the seven or eight years of public school life mental training could be given in the scientific and structural study of foreign modern languages, which should also be, of course, taught colloquially. If the exaggerated time given to dead languages were saved, there would be no difficulty in teaching geography of all kinds, some history, and applied mathematics, and at least one science, in a reasonably efficient way . . . . But, leaving the subject of our public schools and without discussing the curricula of the old Universities, we found, as in primary education, that in this country we began and finished technical education at an age which seemed to him too early.

COMING EVENTS: FEBRUARY—MARCH, 1903.

February.

2nd.—Society of Engineers: Ordinary Meeting at 7.30 p.m.—Meeting: Institution of Marine Engineers.

3rd.—Institution of Civil Engineers: Paper, at 8 p.m.—Royal School of Mines: Old Students' 30th Annual Dinner, Hotel Cecil, at 7 p.m.

4th.—Society of Arts: Paper—"The Port of London," by Dr. B. W. Ginsburg, at 8 p.m.

5th.—Civil and Mechanical Engineers' Society: Paper by Mr. Alphonse Steiger, M.Inst.C.E.—"A Description of a Few of the Most Recent Water Turbine Plants in Great Britain and Abroad," Caxton Hall, Westminster, at 8 p.m.

6th.—Institution of Junior Engineers: Paper, by Mr. W. Garnet Wernham—"Calorimetry," Westminster Palace Hotel, at 8 p.m.

7th.—Birmingham Association of Mechanical Engineers: Paper, by Mr. F. Cockayne—"Softening and Purification of Feed Water for Boilers"—North-East Coast Institution of Engineers and Shipbuilders: Graduates' Meeting, Sunderland.

9th.—Institution of Mechanical Engineers: Graduates Meeting—North-East Coast Institution of Engineers and Shipbuilders: Council Meeting, Newcastle—Institution of Marine Engineers meet.

10th.—Institution of Civil Engineers: Paper, at 8 p.m.

11th.—Liverpool Engineering Society: Paper—"Notes on Progress of Hydraulic Power Supplies," by Mr. F. J. Haswell, M.I.Mech.E.

12th.—Institution of Electrical Engineers, meet at 8 p.m.

13th.—Institution of Civil Engineers: Paper for Students at 8 p.m.

14th.—Manchester Association of Engineers: 47th Anniversary Dinner at 7 p.m.—Birmingham Association of Mechanical Engineers: Annual Dinner—Institution of Junior Engineers: 18th Anniversary Dinner, Victoria Hall, Hotel Cecil, at 7 p.m.—North of England Institute of Mining and Mechanical Engineers: General Meeting at 2 p.m.; Council Meeting at 1.30 p.m.

16th.—Institution of Marine Engineers meet.

17th.—Institution of Civil Engineers: Paper, at 8 p.m.

19th.—Institution of Mining and Metallurgy meet.

20th.—Institution of Mechanical Engineers: Annual General Meeting.

21st.—North-East Coast Institution of Engineers and Shipbuilders: General Meeting, West Hartlepool.

23rd.—Institution of Marine Engineers meet.

24th.—Institution of Civil Engineers: Paper, at 8 p.m.

25th.—Liverpool Engineering Society: Paper—"Temporary Dams," by Mr. Geo. Cecil Kenyon, Assoc.M.Am.Soc.C.E.

26th.—Institution of Electrical Engineers: Meeting.

27th.—Institution of Civil Engineers: Students' Meeting at 8 p.m.

28th.—Manchester Association of Engineers: Paper, by Mr. James Atkinson, of Manchester, on "Gas Engines with Recent Developments," at 7 p.m.—North-East Coast Institution of Engineers and Shipbuilders: Graduates' Meeting, Newcastle.

March.

2nd.—Society of Arts: Paper—"Hertzian Wave Telegraphy in Theory and in Practice" (first lecture), by Prof. J. A. Fleming, M.A.—Society of Engineers: Ordinary Meeting at 7.30 p.m.—Institution of Marine Engineers meet.

3rd.—Institution of Civil Engineers: Paper, at 8 p.m.

5th.—Institution of Civil and Mechanical Engineers: Paper—"The Production of Power by Means of Gas Producers and Engines," by Mr. R. W. A. Brewer, A.M.Inst.C.E., at 8 p.m.

6th.—Institution of Junior Engineers: Paper—"Practical Notes on the Use and Maintenance of Electric Motors for Factory Purposes," by Mr. W. T. George, at 8 p.m.

7th.—Birmingham Association of Mechanical Engineers: Paper—"The Mechanical Engineering of Modern Collieries," by Mr. W. Barditt.

SOME BOOKS OF THE MONTH.

"AN INTRODUCTION TO CELESTIAL MECHANICS."

By F. R. Moulton, Ph.D., Instructor in Astronomy in the University of Chicago. New York: The Macmillan Company. London: Macmillan and Co., Ltd. 384 pp. 14s. net.

THIS scholarly work is the outcome of a course of lectures delivered annually by the author during the last six years at the University of Chicago, and will be found of the utmost use to those who desire to become familiar with the processes by which astronomers interpret and predict celestial phenomena. Starting with fundamental principles and definitions, Mr. Moulton, in steps of progressive difficulty, proceeds to dissertations on rectilinear motion, central forces, the potential and attraction of bodies, the problem of two bodies, the general integrals of the problem of *n* bodies, the problem of three bodies, perturbations, and the determination of the elements of parabolic and elliptical orbits. The problems throughout are clearly stated, and the student will find many valuable references which serve as a key to further reading on this somewhat abstruse subject.

"FOWLER'S MECHANICAL ENGINEER'S POCKET-BOOK FOR 1903."

Edited by William H. Fowler, Wh.Sc., M. Inst.C.E. Scientific Publishing Co., Manchester. 441 pp. 2s. 6d.

A HANDY book of reference, which is designed principally for the use of the mechanical engineer. It presents a vast number of useful facts and figures, carefully indexed, revised and brought up to date year by year. The present issue includes many new tables calculated to help the engineer in his daily work; while substantial additions have been made to the sections relating to steam boilers and engines, which embody the latest information available respecting recent developments in connection with superheating, oil burning water-tube boilers, etc.

"THE COLLIERY MANAGER'S POCKET BOOK ALMANAC, AND DIARY FOR THE YEAR 1903":

Being the Thirty-Fourth Year of Publication. Edited by Professor R. A. S. Redmayne, M.Sc., M.Inst.M.E., F.G.S., of the Mining Department, Birmingham University. Colliery Guardian Company, Ltd. Cloth, 2s.; roan gilt, 3s.; russia leather, 4s.

THE colliery manager or official who becomes familiar with the pages of this useful compilation, carrying it in his pocket for daily reference, will be well repaid for the trouble. Facts, tables, and statistics abound, and the following headings of sections will show the wide field covered: Chief Events of the Year, Coal Cutting by Machinery, The Coalfields of the United Kingdom, Mineral Statistics, Mining Institutes, Inspectors, The Examinations, Coal, Strength of Materials, Machinery, Ventilation, Valuation, and Surveying.

"AN INTRODUCTION TO THE STUDY OF METALLURGY."

By Sir W. C. Roberts-Austen, K.C.B., D.Sc., F.R.S. Fifth edition, revised and enlarged. Charles Griffin and Co., Ltd. 516 pp. 18s.

THIS well-known treatise now make its reappearance in a fifth edition, thoroughly revised and with considerable additions. The metallurgical student who opens the volume for the first time is confronted with a prospect that is at once attractive and fascinating. The usual sections devoted to specific metals are absent, and minute descriptions of processes are avoided in favour of typical appliances considered in relation to groups of metals. The work has also the advantage of great liberality in the matter of illustration, and includes a series of excellent plates showing micro-sections of different varieties of steel. More advanced students can read this volume with interest and advantage; and a complete index renders it useful as a work of reference.

(Owing to pressure upon our space a number of Reviews are held over until [illegible])

CATALOGUES AND TRADE PUBLICATIONS.

The Hunslet Engine Company, Ltd., Hunslet Engine Works, Leeds.—Catalogue of Locomotives, 1903.—Although merely described as a catalogue, this handsome volume of 256 pages, bound artistically in red leather, presents a complete synopsis of English locomotive practice. Every right hand page has a half-tone illustration, and the accompanying details are so carefully tabulated that a comparison between the different types of engines can be made with the greatest ease. From the introduction we learn that the company have re-organized the motive power employed in the works, which are now entirely equipped with electrical plant of the latest type, so that they are most favourably placed for dealing with the production of their specialities, viz. : Tank locomotives up to 40 tons empty weight, and the lighter class of tender engine. At these works are manufactured locomotives for every variety of purpose and gauge. The catalogue is divided into the following sections : (1) English standard and broad gauges ; (2) narrow gauges ; (3) Bogie engines ; (4) locomotive tender engines. At the end of the volume will be found some useful notes on Tractive Force, memoranda, and indexes.

Greenwood and Batley, Ltd., Leeds.—Three illustrated catalogues of excellent design treating exhaustively of the firm's specialities in machine tools, oil mill machinery, and the De Laval patent steam turbine. A well printed book of 300 pages covers the first-named, and includes all kinds of milling and planing machines, lathes, hammers, etc. ; while not less than 149 pages and cover, comprising another book of equal merit, are devoted to the various kinds of oil mill machinery manufactured by the firm. An album containing some 70 plates of large size with full-page half-tone blocks of the best make, portrays to great advantage the works (with exterior and interior views), and manufactures of the English De Laval Steam Turbine Co., Ltd., of Leeds, of which Messrs. Greenwood and Batley are the patentees for Great Britain and Ireland, the British Colonies and Dependencies, Egypt, China and Japan. Their specialities include steam turbine motors, dynamos, pumps, blowers and ventilators, rotary fire engines, locomotive and train lighting equipments, marine light-generating sets, etc.

Lancaster and Tonge, Ltd., of Pendleton, Manchester.—A "Slate Catalogue" of original design, comprising a unique cover printed to represent an ordinary slate with frame, and sixteen pages descriptive of the "Lancaster" patent steam traps, pistons, piston rings, packings, blocks, coils, valves, etc., with prices. Four pages are devoted to an illustrated description of the "Lancaster" patent steam dryer, which is an apparatus for separating water from steam, embodying both accepted methods—*i.e.*, centrifugal force and gravity. This steam dryer, when combined with stop valve, takes the place of the starting valve on an engine.

Edward G. Herbert, Ltd., Cornbrook Park Works, Manchester.—"Labour Saving Tools."—A series of leaflets illustrating and describing a selection of machine tools. One of the most important is a quick cutting eccentric sawing machine (Herbert's Patent) This machine embodies a new principle, which it is claimed, renders the hack saw for the first time applicable for heavy work, and can be used for girders and bars up to 20 in. by 12 in. Other specialities are an automatic cutting-up machine, which cuts up bars or pipes into pieces of uniform length "without any attention" ; a vertical sawing machine, which can be used for a variety of work not possible on an ordinary hack saw. A "Radial Slot" Face Plate Dog, which has the advantage of converting an ordinary lathe into a powerful chuck "at very low cost" ; an improved "Rapid" Centring Tool ; a Reversible Machine Vice, etc., etc. An Exhaust Head (Fletcher's Patent) calls for special mention if only by reason of its novel design. It is so constructed that, being open to the atmosphere, both top and bottom, it is not possible for the Head to set up back pressure. Its discharge, which consists of dry steam only, is practically noiseless, and the ejection of oil and water is prevented. Other advantages are also claimed for this Exhaust Head.

Messrs. Blake and Knowles, Steam Pump Works, Ltd., London.—This well-known firm have just issued three catalogues—a "General" and two "Special." The first named is a well-designed little booklet of 134 pages, and cover, profusely illustrated, and, as its name implies, deals in a general way with the many specialities in Pumping Machinery which are supplied by this firm. In addition the book contains some useful information on the weights and comparative value of wood fuel, the duty of steam engines, the weights and capacities of various standards of oil, etc. ; also an index of code words and a general telegraphic code which foreign correspondents will find very useful. No. 1 "Special" deals with power pumps, air compressors, water-works pumping engines, condensing apparatus, boiler feed, fire, hydraulic, and light service pumps, also pumps of special metals for handling acids and gases of every kind. The following short quotation from the introduction is interesting : "While the fact that we manufacture *every variety* of pumping machinery, whether for operation by steam, air, hydraulic, electric, or any other power, is, in itself, sufficient to show that our position is unprejudiced, there are certain elementary advantages in favour of electrical operation, as compared with other methods, which must always have great weight, unless counterbalanced by economical considerations due to special circumstances." No. 2 "Special" catalogue contains a series of general specifications of the "Blake Duplex Corliss Air Compressor," in various styles and types. This machine, we are informed, is specially adapted for use in dye works, pulp and paper mills, etc., for exhausting air and vapours.

Fairbank Brearley, Central Engine Works, Shipley, Yorks.—A revised edition of this firm's catalogue is just to hand. It comprises an illustrated booklet of 24 pages and cover, describing the various types of horizontal, tandem and coupled, compound and vertical steam engines. A very useful adjunct to this catalogue is provided in the many specifications of measurements, etc., dealing with each particular class of engine.

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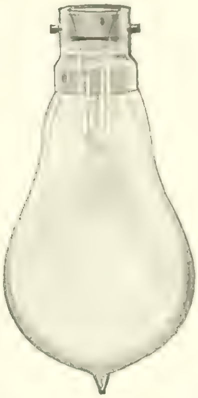

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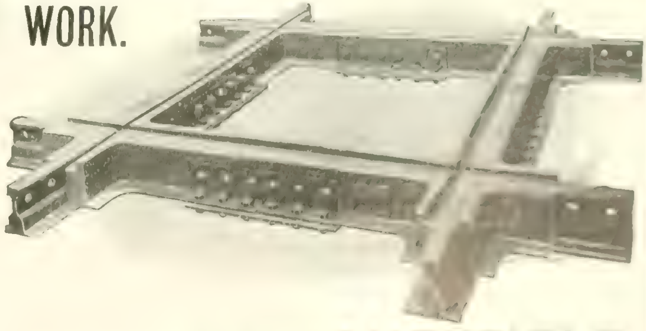

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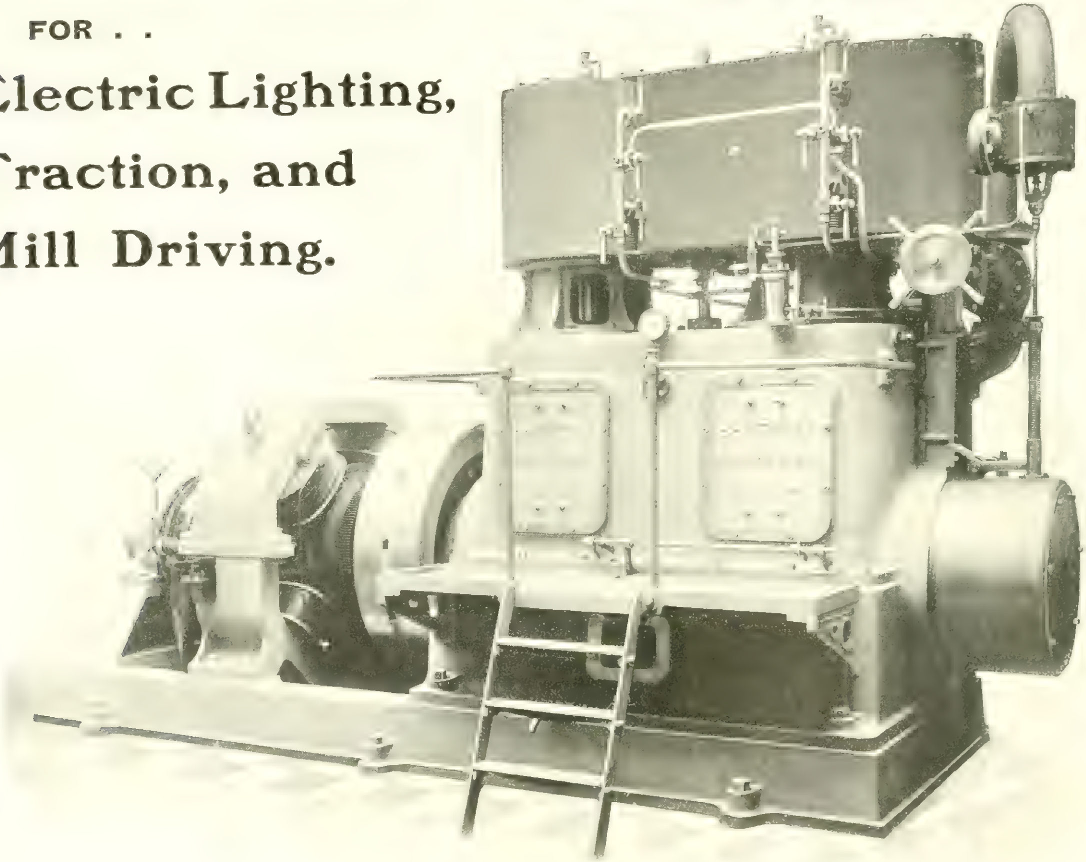

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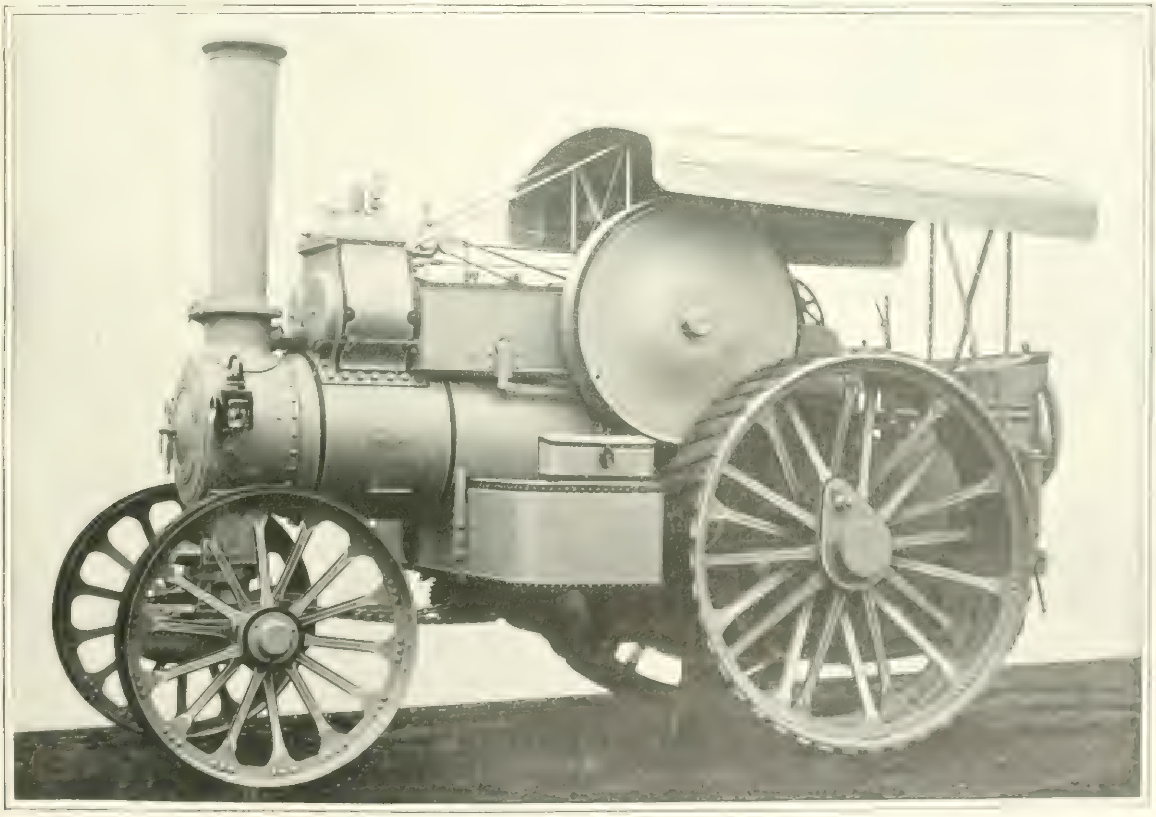

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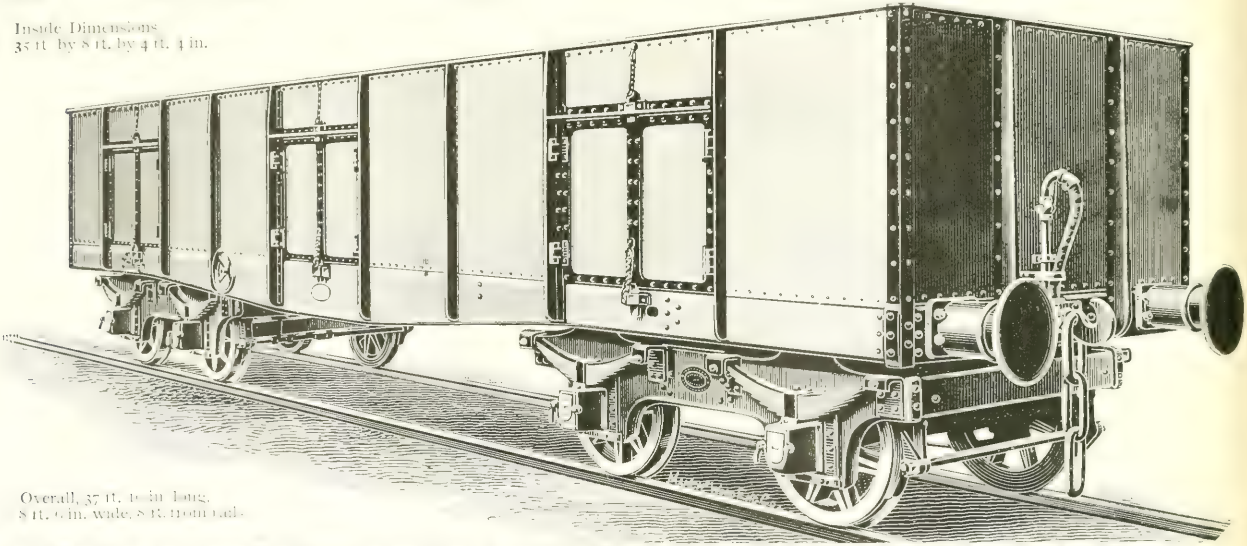

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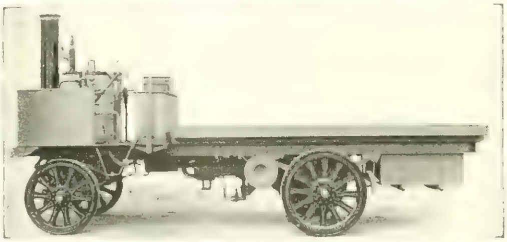

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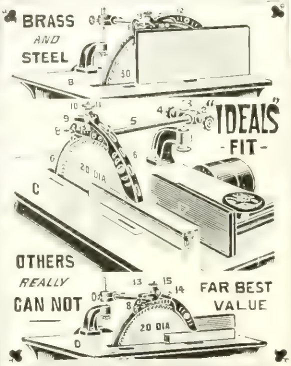

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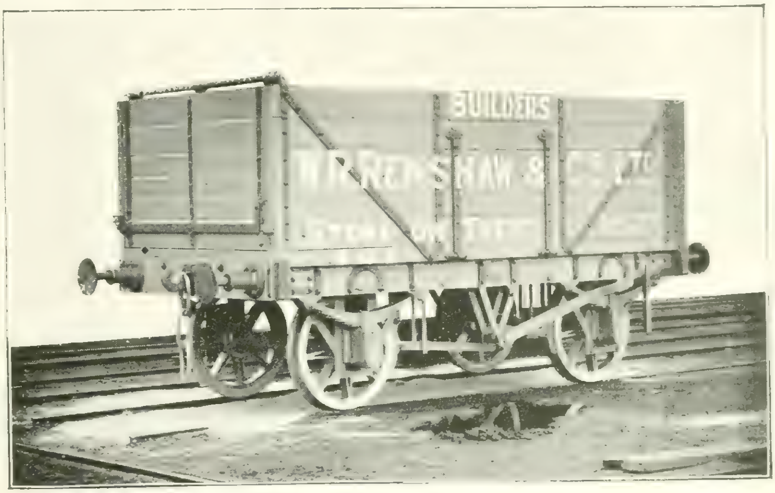

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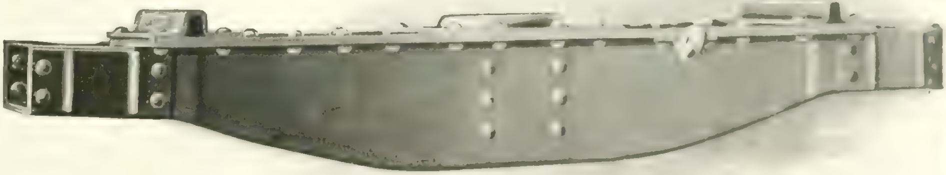

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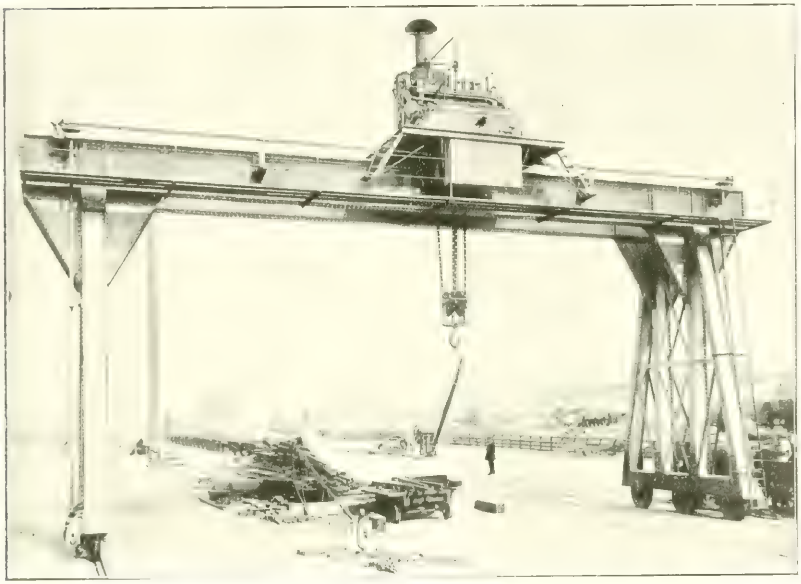

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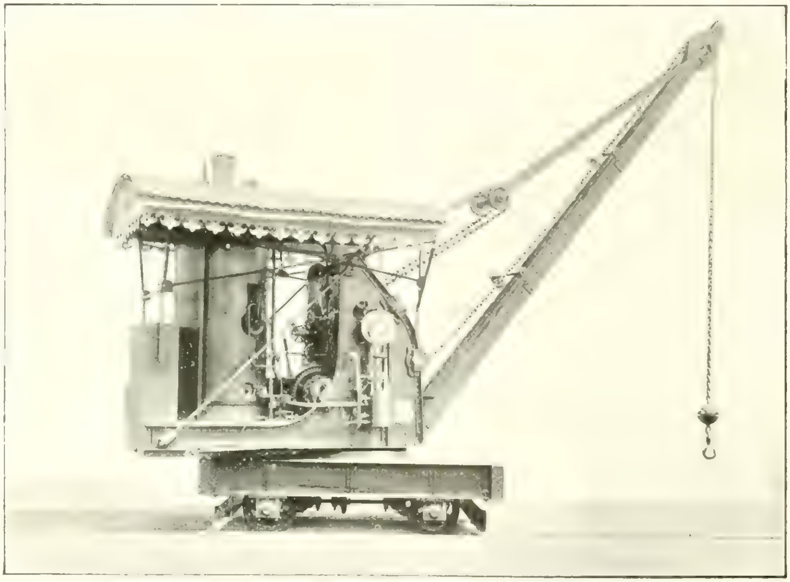

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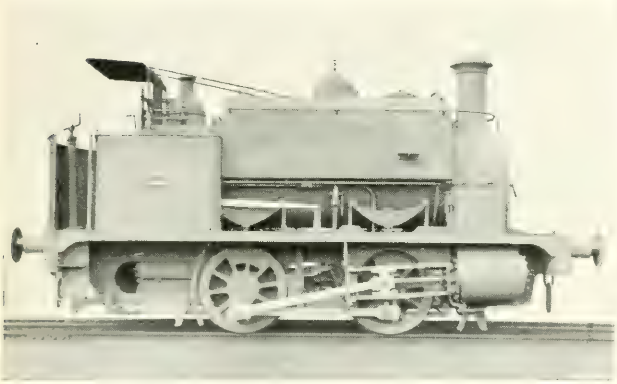

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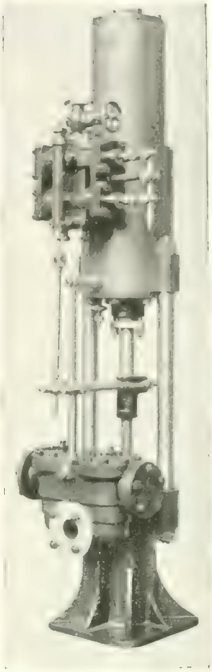

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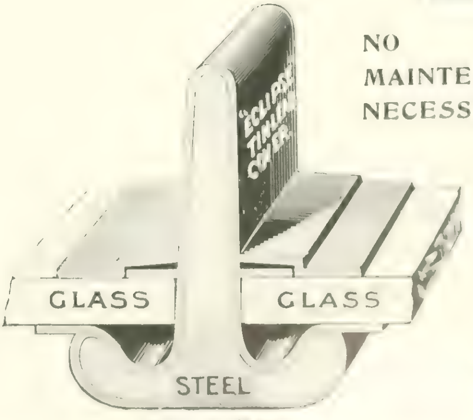

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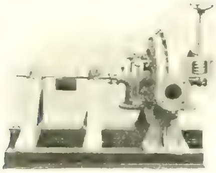

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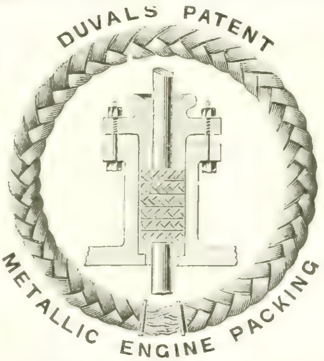

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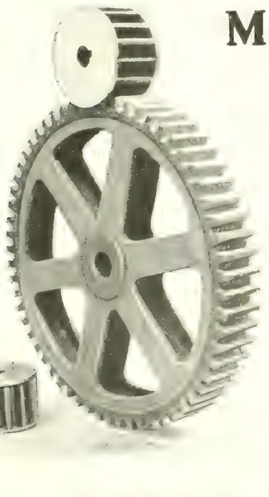

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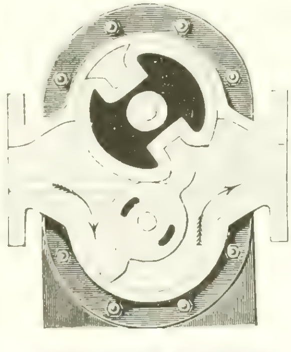

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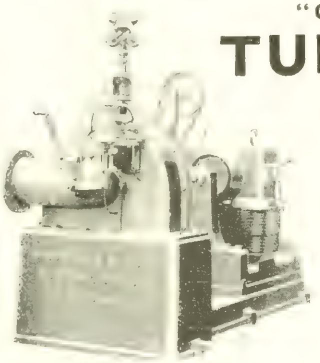

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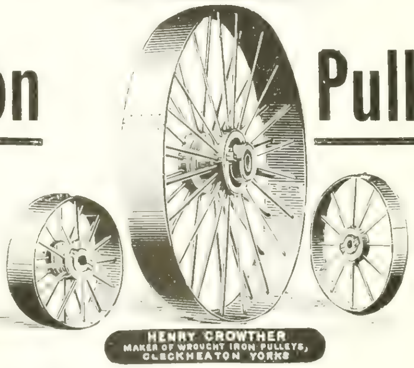

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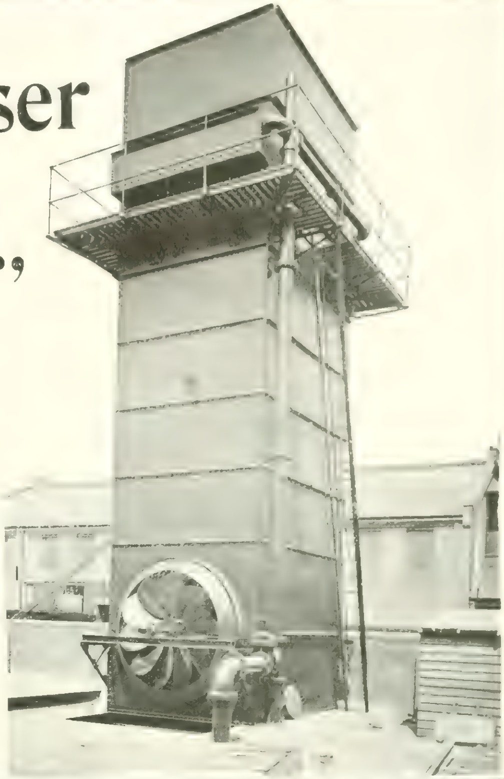

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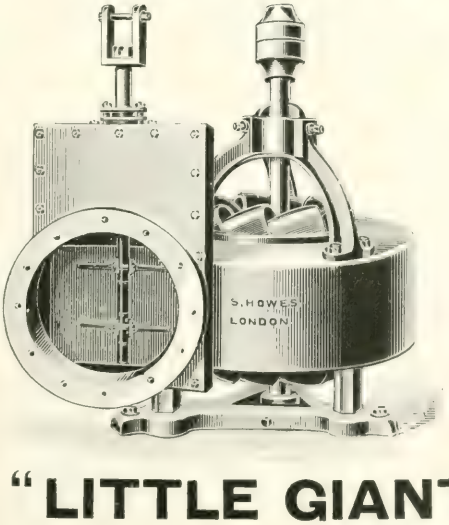

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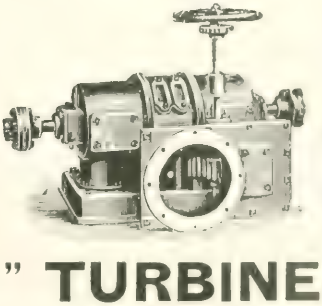

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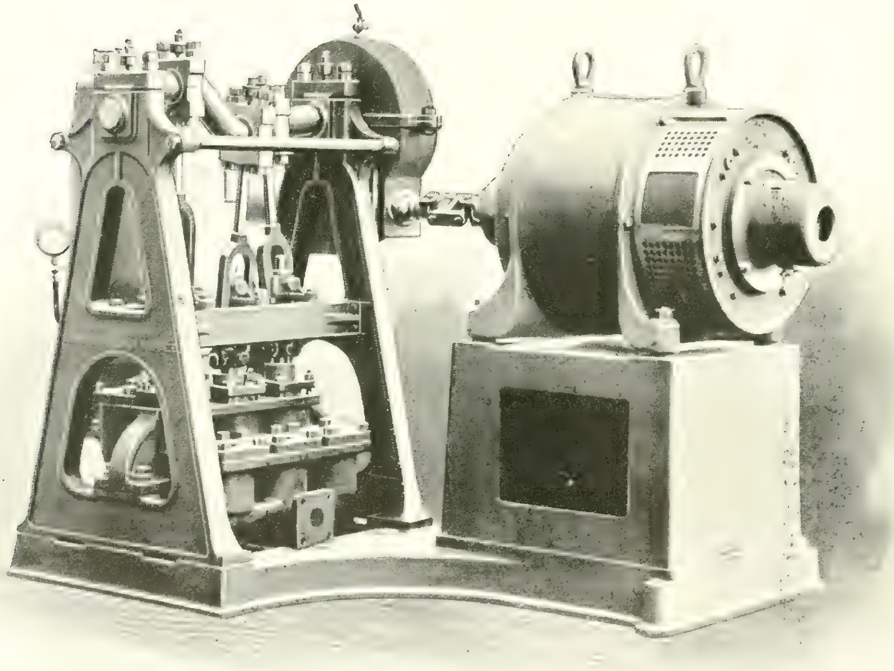

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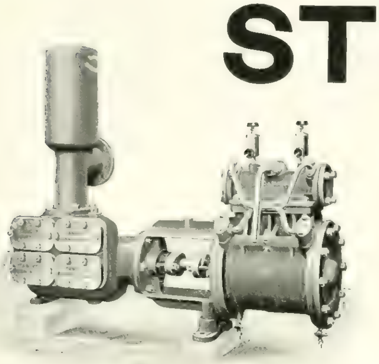

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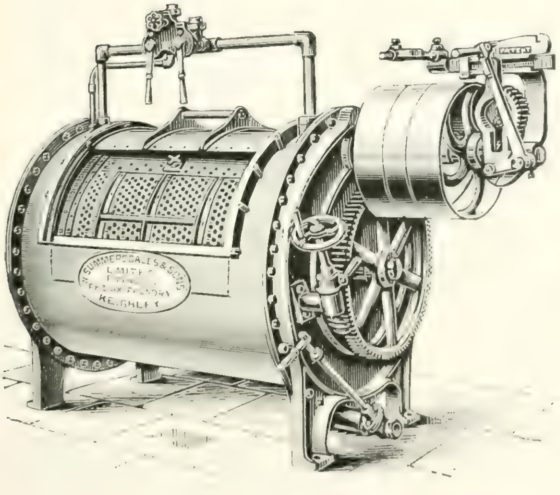
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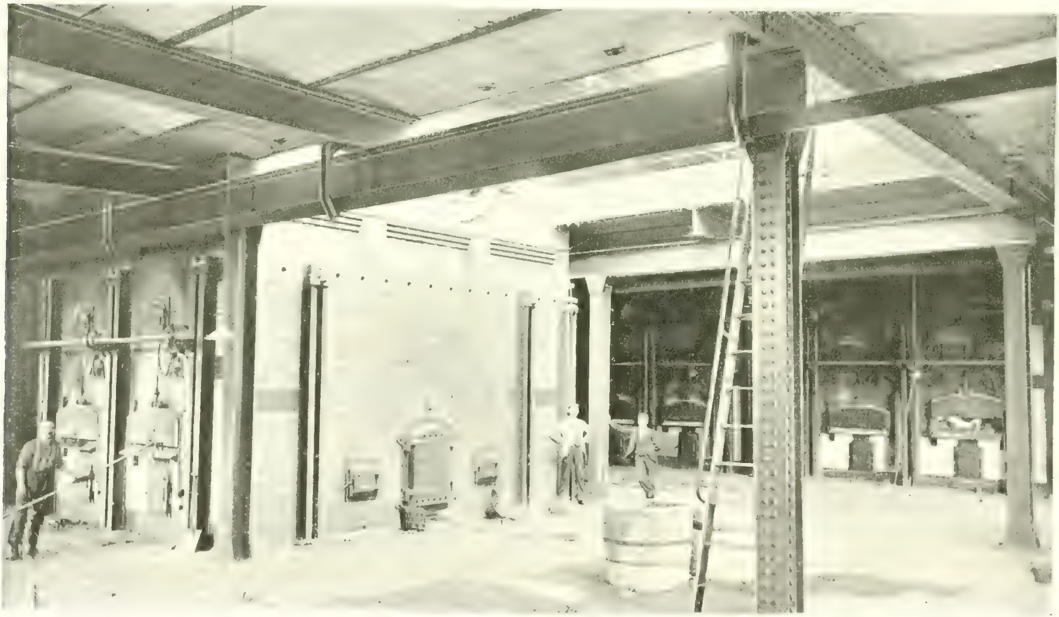

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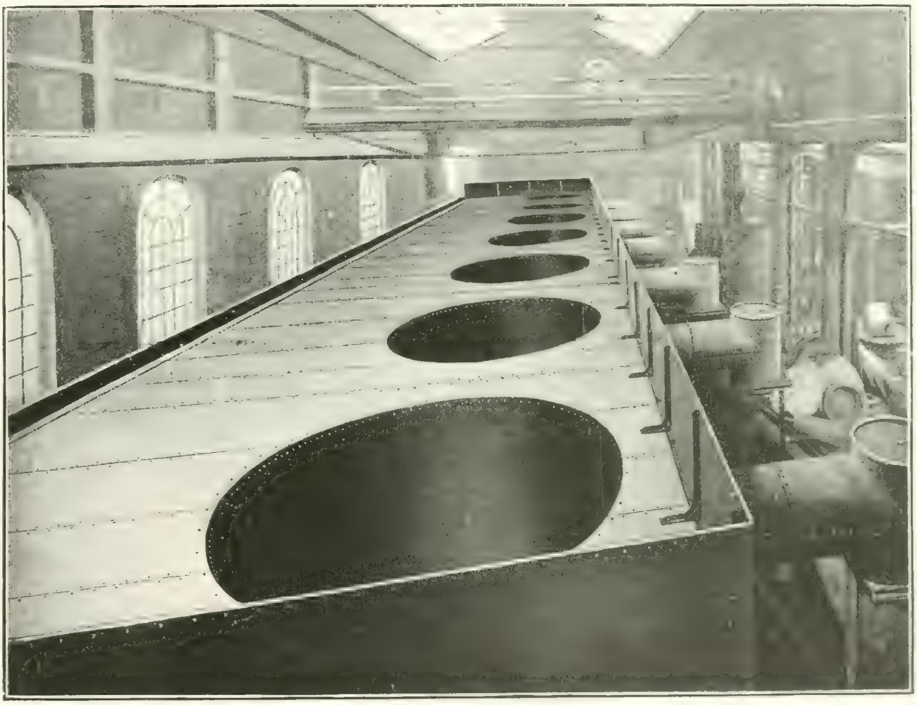

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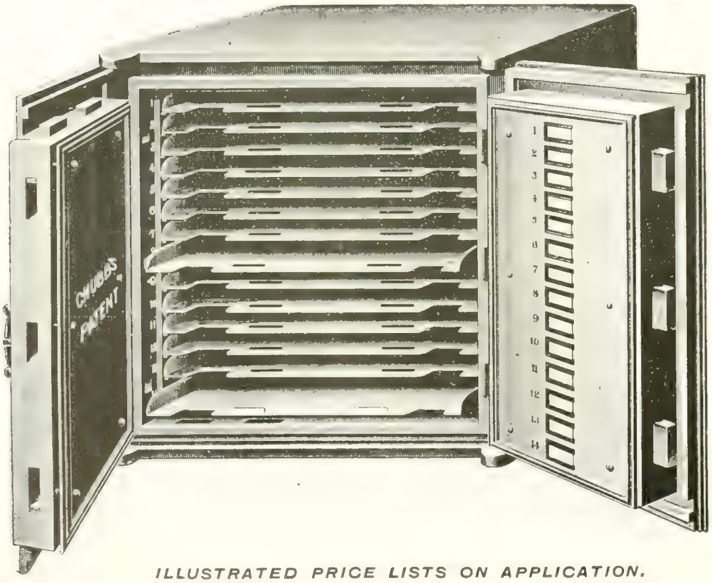

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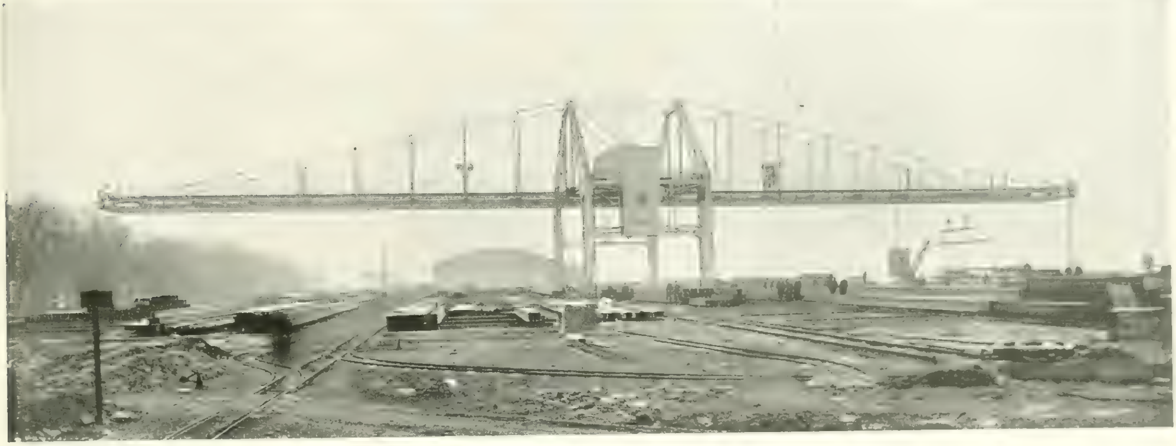

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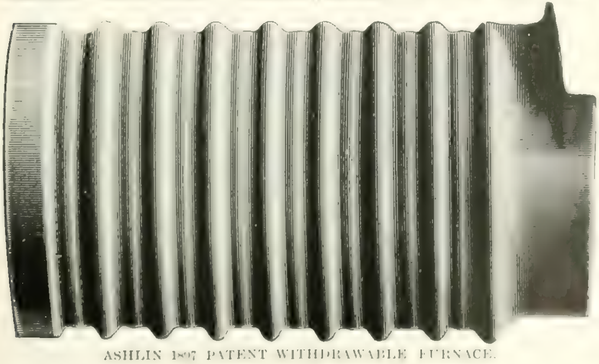

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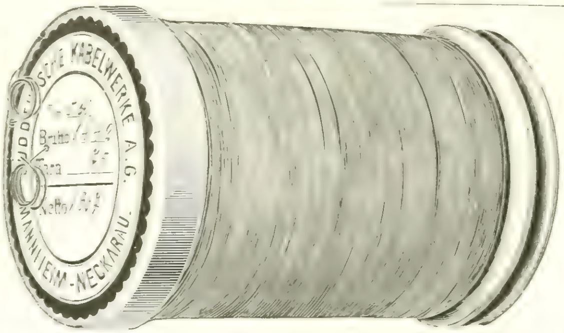

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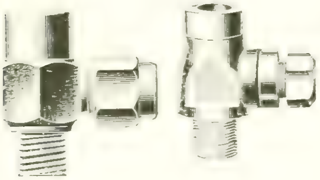

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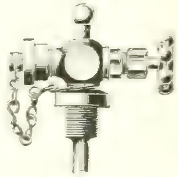

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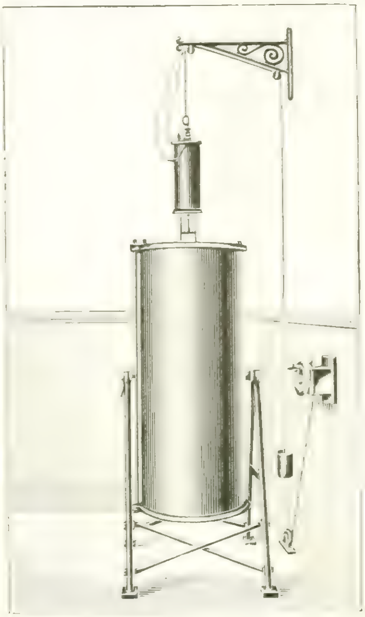

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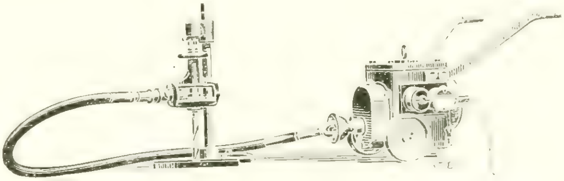

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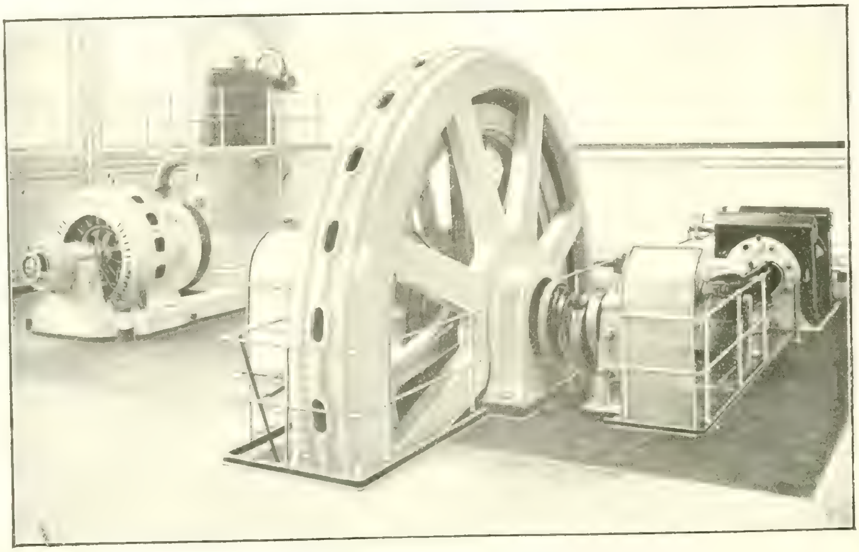

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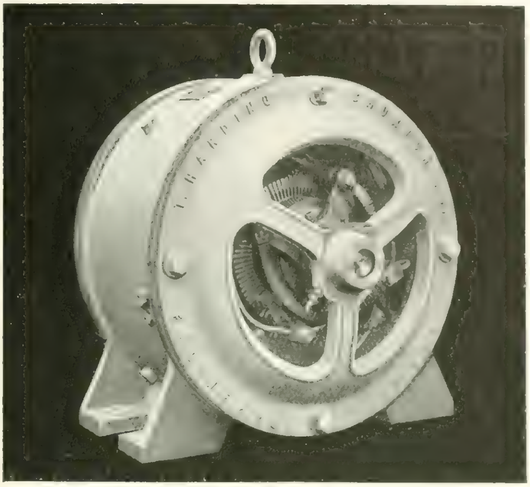

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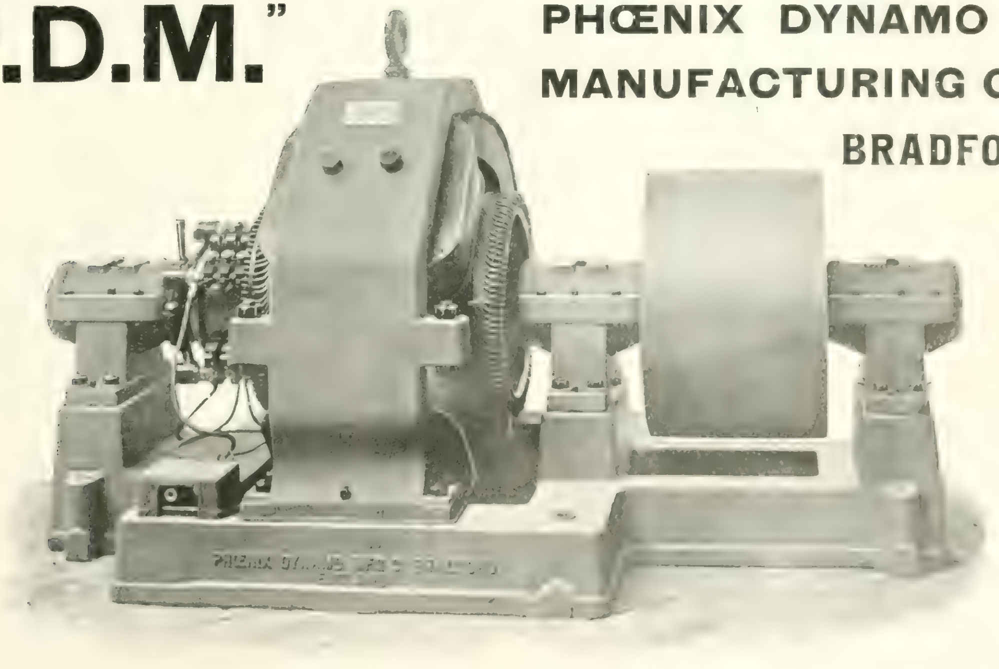

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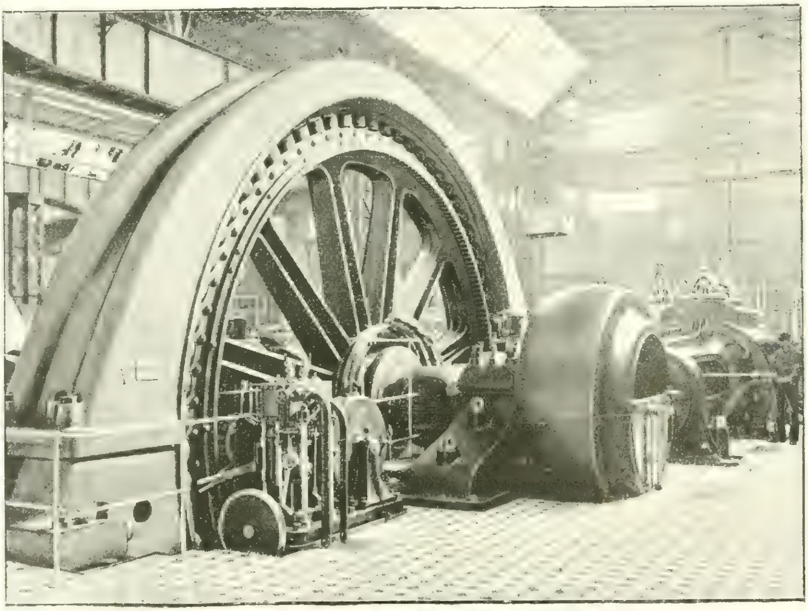

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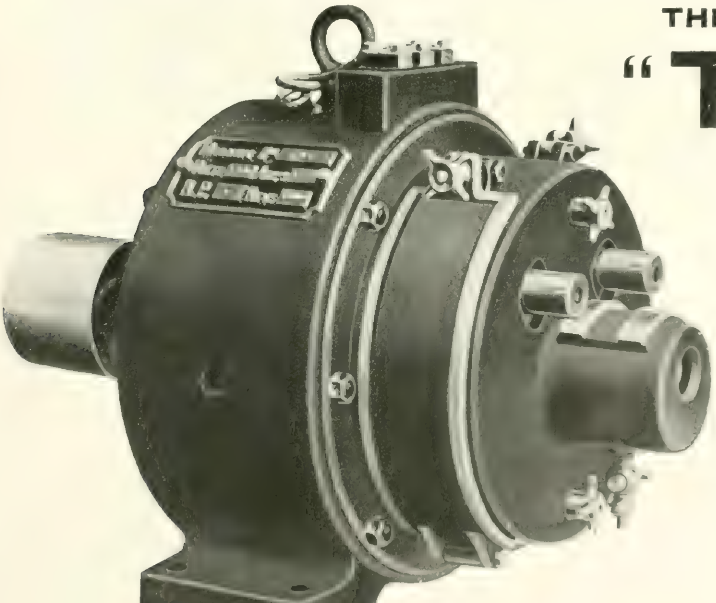

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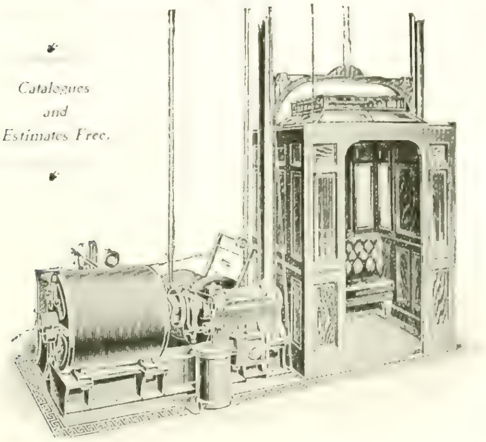

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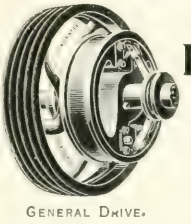
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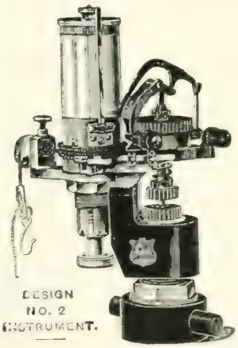
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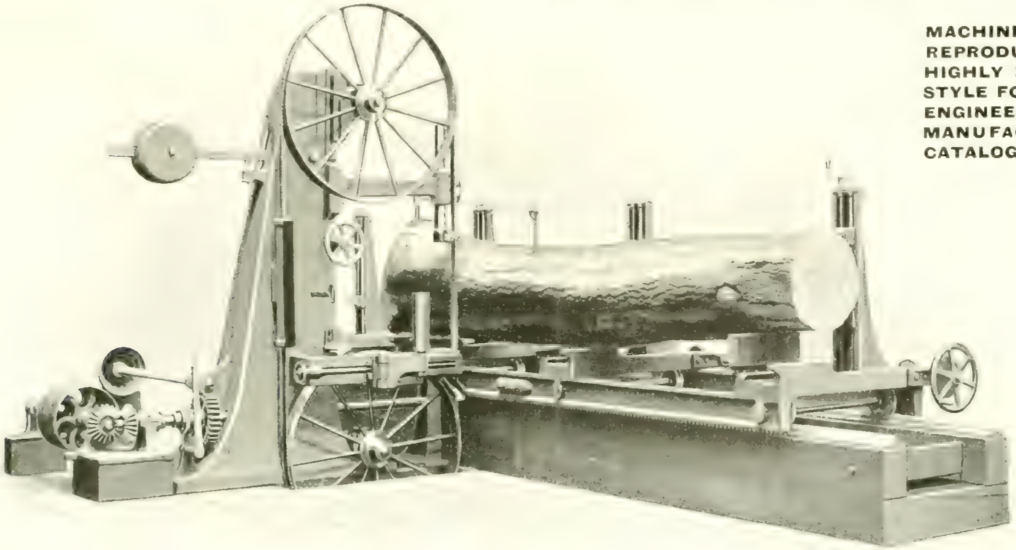

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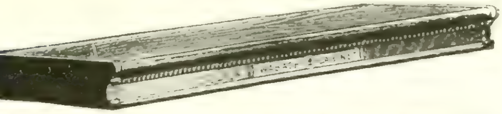

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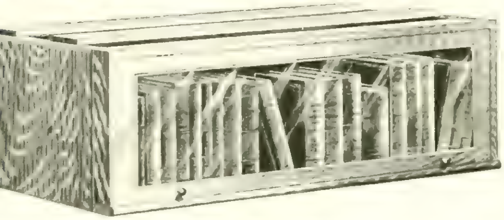

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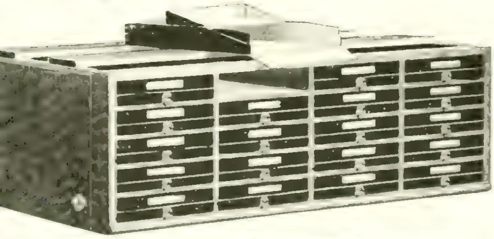

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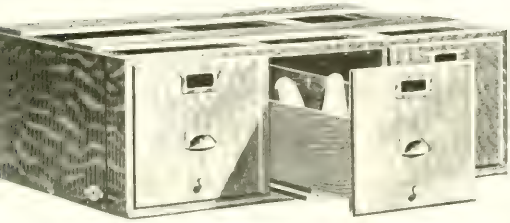

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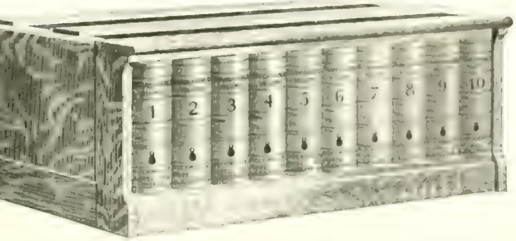

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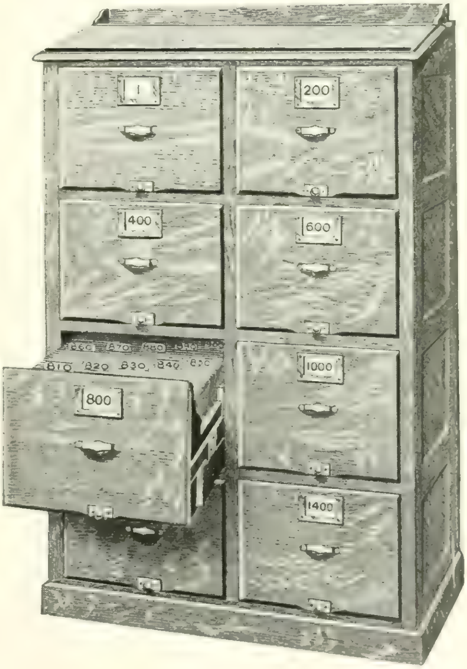

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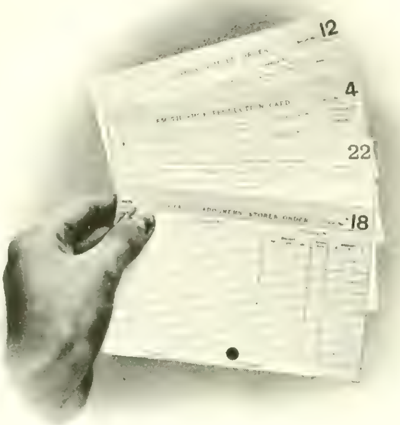

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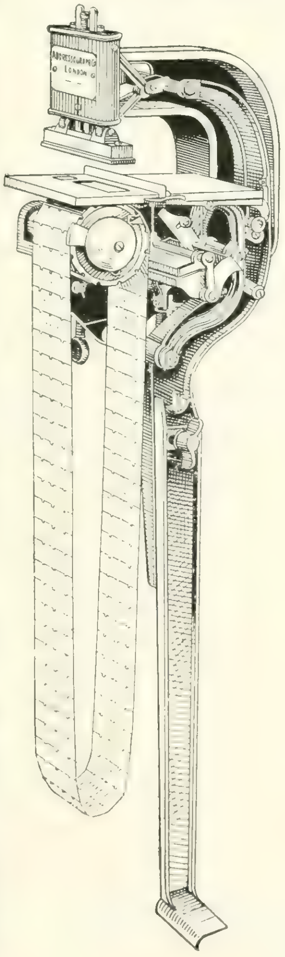

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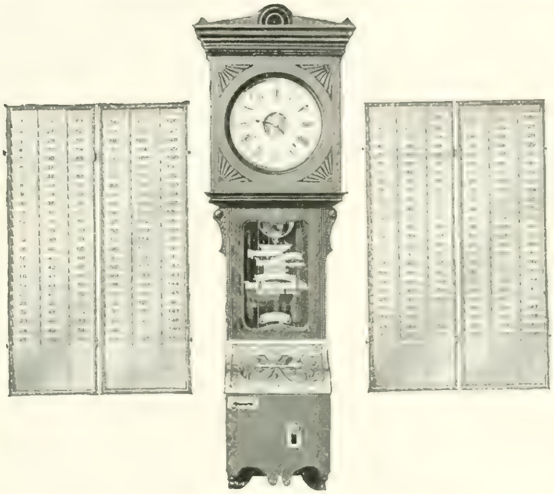

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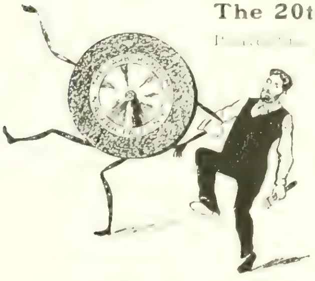

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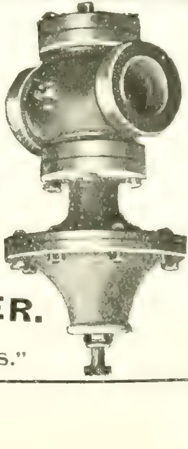

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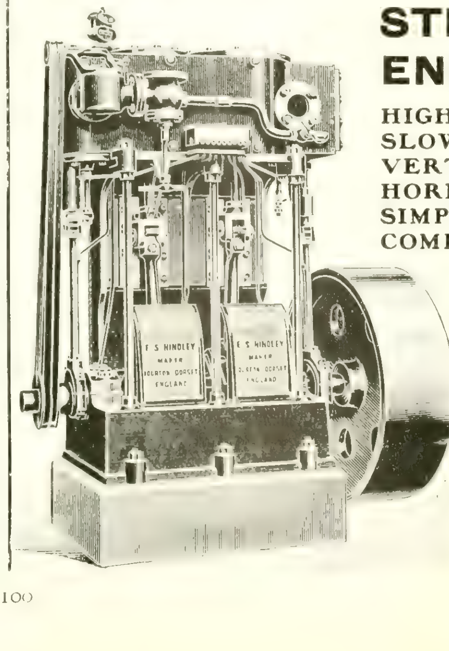
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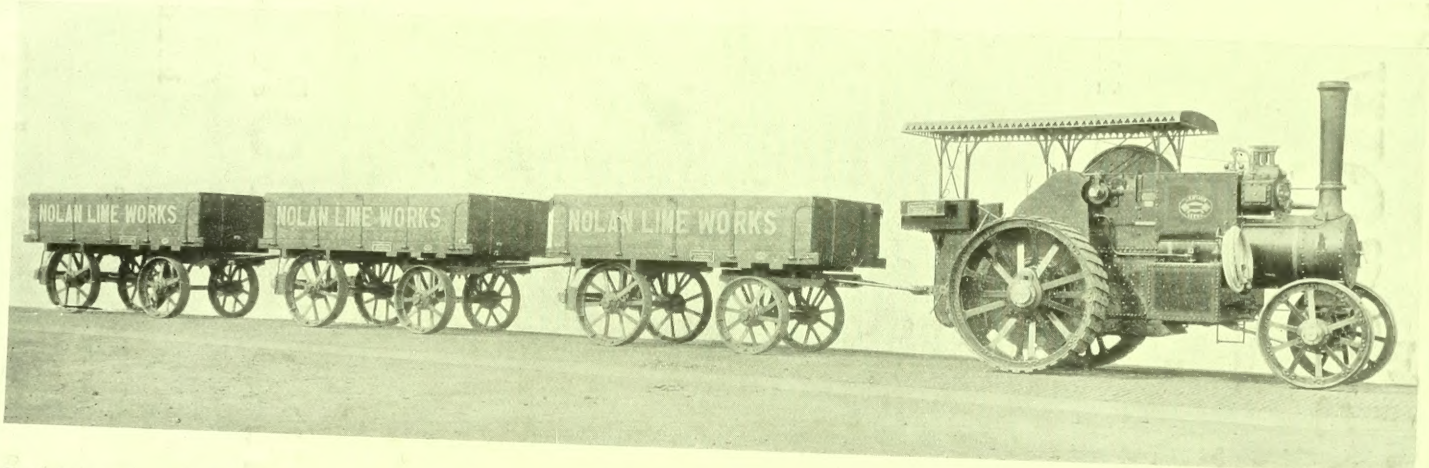

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